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ORIGINAL ARTICLES.

I.—On the American Palæozoic Gasteropod, *Trematonotus* (Hall emend. P. Fischer), and its Identification in Britain; with Description of a New Species.

By R. Bullen Newton, F.G.S.;
of the British Museum (Natural History).

(PLATE IX.)

PROFESSOR JAMES HALL'S[1] discovery, in 1864, of his remarkable genus *Trematonotus*, in the Niagara rocks of North America, formed an interesting and valuable addition to his researches in conchological science.

The special features of this shell consist in its Bellerophontoid appearance, coupled with the presence of a single row of isolated perforations on the central part of the dorsal surface. It was somewhat erroneously regarded by its author as a sub-genus of *Leveillia*[2] (*Porcellia*),[3] though its unique characters would mark it as a distinct form, and probably more intimately related to the well-known *Haliotis* of our modern seas than to any other known shell.

Mr. F. B. Meek,[4] in 1866, considered the characters of Hall's genus as affording the evidence required to finally prove the Prosobranchiate affinities of the Bellerophontidæ, an opinion which the late Professor de Koninck[5] advanced as long ago as 1844 after a careful comparison of the genus *Emarginula* with the extinct *Bellerophon*. The views of the Belgian palæontologist on this point were very partially recognized, and only received adoption from Alcide d'Orbigny[6] in 1852, and Pictet[7] in 1855, since which dates they were classed with the Heteropods, until Meek's observations led to a reconsideration of the subject, and a general acknowledgement that the banded shells of the Prosobranchiate Mollusca must henceforth include the family of the Bellerophontidæ.

The type species of *Trematonotus*, and the only one then described, was *T. alpheus*, a name since ignored in favour of McChesney's

[1] Eighteenth Report Regents University, New York, 1864, p. 347; Twentieth ditto, 1867, pl. xv. figs. 23, 24.
[2] R. B. Newton, Geol. Mag. 1891, Pl. VI. p. 202.
[3] C. Léveillé, Mém. Soc. Géol. France, 1835, vol. 2, part 1, p. 39.
[4] Proc. Chicago Ac. Sci. 1866, vol. 1, p. 9.
[5] Desc. Animaux Foss. Carb. Belgique, 1844, pp. 334–338.
[6] Cours élèm. Paléontologie Géologie, 1852, vol. 2, p. 33.
[7] Traité Paléontologie, 1855, ed. 2, vol. 3, p. 287.

Bucania Chicagoensis[1] of an earlier date, and which is doubtless synonomous with it, as pointed out by S. A. Miller.[2] A second species was recorded by Messrs. Hall and Whitfield,[3] in 1875, as *T.* (?) *trigonostoma*, the authors placing a query against the genus because they were unable to distinguish the perforations in consequence of the obscurity of the dorsal region of their specimen. Both these species were obtained from the Niagara formation of Illinois and Ohio in the United States.

Another Palæozoic shell exhibiting a single row of openings on its whorls is d'Orbigny's *Polytremaria*,[4] founded on De Koninck's type of *Pleurotomaria catenata*[5] from the Carboniferous Limestone of Belgium. This form is sufficiently distinct not to be confounded with *Trematonotus*, being a small trochiform shell possessing a wavy band round its volutions, resulting in a series of what may be termed pseudo-perforations. De Koninck,[6] following d'Orbigny,[7] relegated it to the Haliotidæ.

The genus *Salpingostoma*[8] of F. Roemer, is also a shell with Bellerophontoid characters but having a wide umbilicus and bearing on its dorsal region a single elongate slit considerably removed from the apertural margin. Its type is the *Bellerophon megalastoma*[9] of Eichwald from the Silurian rocks of Russia. Dr. Paul Fischer makes reference to another perforate shell under the name of *Gyrotrema*,[10] but this is ascertained to be merely a manuscript genus of Barrande's which has been used for list purposes by Dr. J. J. Bigsby[11] and consequently of no zoological value until it is described and figured.

The Silurian genus *Tubina*[12] from Bohemia has three rows of tubular spines on its dorsal region, which, however, are rarely preserved, as they become detached and then have all the appearance of true perforations. One specimen of this genus in the British Museum exhibits the spines *in situ* and is the same species as that figured in Sir Richard Owen's "Palæontology" under the name of *Taubia armata*, Barrande (MS.) This genus is placed by Dr. Fischer in the Delphinulidæ.

The character of the orifices in *Trematonotus* was considered of sufficient importance by Mr. Ralph Tate[13] to claim the genus as a member

[1] Trans. Chicago Ac. Sci. 1859, vol. 1, pl. viii. figs. 4, 5, p. 69.
[2] North American Geology and Palæontology, 1889, p. 428.
[3] Rep. Geol. Surv. Ohio, 1875, vol. 2, part 2, pl. 8, fig. 5, p. 146.
[4] Prodrome Paléontologie, 1849, vol. 1, p. 122.
[5] Desc. Anim. Foss. Carb. Belgique, 1844, pl. xxxii. fig. 1, p. 374.
[6] Faun. Calc. Carbonif. Belgique, Ann. Mus. R. Hist. Nat. Belgique, 1883, vol. 8, part 4, p. 10.
[7] Cours élèm. Paléontologie, 1852, vol. 2, p. 21.
[8] Lethœa geognostica (Palæozoica) 1876, pl. v. fig. 12.
[9] Silurische Schicht. Esthland, 1840, p. 111.
[10] Manuel Conchyl. 1885, p. 854.
[11] Thesaurus Siluricus, 1868, p. 167.
[12] A manuscript name of Barrande's. Genus first figured and described by S. P. Woodward, in Sir Richard Owen's "Palæontology." 1860, pp. 71 (fig. 17, No. 8), 78; a fuller description afterwards appearing by Dr. Paul Fischer in his "Manuel Conchyliologie," 1885, woodcut, fig. 587; pp. 830, 831.
[13] Appendix, S. P. Woodward's Manual of Mollusca, 1868, p. 39.

of the Haliotidæ, and by this classification he at once added a far greater antiquity to the family than had hitherto been accorded it. This position for the genus would appear to be the most natural one that could be suggested, since we may fairly assume that the openings on the dorsal surface would, during the life of the mollusc, be used for the ejectment of fœcal matters and for supplying the branchiæ with water, as is known to be the case in the existing *Haliotis*. Some interesting observations on this feature of the recent genus were published a few years ago by Mr. Edgar A. Smith[1] when recording a species of *Haliotis* exhibiting the abnormality of two rows of perforations. In his remarks he gives the position of the anal and branchial regions as immediately beneath the orifices.

Since the publication of the second species of *Trematonotus*, in 1875, nothing further respecting its history has appeared; and it is hoped that a notice of its occurrence elsewhere may prove a subject of considerable interest to the palæontologist.

The new material suggesting this communication consists of two well-marked shells, which appear to be referable to this genus, and belonging homotaxially to the same horizon as the American species, having been obtained from the Wenlock Beds, in the neighbourhood of Dudley. They originally formed part of the celebrated "Johnson Collection," now in the possession of the Geological Department of the British Museum.

Professor Hall's rendering of the generic name was *Tremanotus*; but through an inaccurate compilation of that word Dr. Paul Fischer has made it the occasion of an alteration, and it now appears as *Trematonotus*.[2] The original diagnosis stands as follows:—"Volutions apparently in the same plane; umbilicus on both sides; aperture expanded; the dorsal line pierced by several oblong perforations."

Trematonotus Britannicus, n.sp.

Specific characters.—Shell symmetrical, discoidal, cordiform, with few volutions; umbilicus obscure; dorsal surface narrow near spiral region, then suddenly expanding, convex, thinning out towards margin with a gradual reflection; central ridge composed of slightly raised elongate perforations which cease after extending to about three-fifths the length of the shell; ornamented with rather closely-set wavy striæ, running parallel to the central ridge, which are directed outwards as they reach the expansion, and marked transversely with several arched lines of growth. The ventral surface shows a much expanded aperture, wedged in which is the elliptically-shaped whorl containing the inner volutions; this whorl bears traces of the perforations which are probably more or less filled up; the body-chamber is cordiform and deep and is bordered by a wide and spreading lip which is thin, slightly convex, and ornamented with oblique radiating striæ; aperture entire.

Dimensions.—Height = 90 mm.; width (maximum) = 65 mm.;

[1] Annals, 1888, pp. 419–421.
[2] Manuel Conchyl. 1885, p. 854.

length of ventral aspect of volution = 35 mm.; width of ventral aspect of volution = 18 mm.; width of the lip = 15 mm.

Observations.—The most perfect of the two specimens shows both surfaces but dorsally the expansion is obliterated by matrix. The perforations, though perhaps not quite so regularly placed as observed in Hall's drawing of the type species, are nevertheless prominent and unmistakeable. They are somewhat obscure on the ventral face of the whorl, where probably they are more or less filled up; but slight risings and depressions in the central ridge seem to indicate their presence. Viewed dorsally this character is more striking. Here the holes are narrow and elongate, the central one being longest; they are raised and quite distinct, with a depression between each. After extending to within about three-fifths the length of the shell the perforations cease and the central ridge becomes more or less merged in the longitudinal striæ which ornament the fossil. Adherent to the surfaces of this specimen are some imbedded examples of *Spirorbis Lewisi* (*tenuis*),[1] and some Polyzoon growths. The second specimen is a cast of the dorsal surface only, in which the siphonal openings are present but fewer, thus forming a distinction which might be a reasonable excuse for treating it as a separate species but in the absence of additional material it is perhaps safest to regard it as the same. The expansion is absent but the radiating striæ observed near the spiral region are sufficient to indicate its existence when the shell was more perfect. The margins in both specimens are quite entire, there being no evidence of an apertural sinus. The umbilical areas have suffered through pressure and are consequently obscured, so that their exact limits cannot be accurately appreciated.

This new species bears a resemblance to *Bellerophon dilatatus*[2] of J. de C. Sowerby, from the Ludlow rocks of Burrington; but that shell is more largely umbilicated and its central ridge is non-perforate. An unfortunate mistake regarding this species was made by Mr. S. P. Woodward, who figured on plate xiv. fig. 28 of his celebrated "Manual of the Mollusca" the *B. dilatatus* and named it *Bellerophon expansus*, a shell which has a deeply sinuate margin and is altogether quite distinct from the more robust form of the other species which has its margin entire.

This error has been copied by Dr. Paul Fischer, who, using the same plates for his "Manuel" as illustrated Woodward's earlier work, suggests a relationship between *B. expansus* and *Trematonotus*, the *B. dilatatus* being clearly the form meant in his reference. After an examination of several specimens of this species, both at the Geological Museum, Jermyn Street, and at the British Museum, no trace of perforations could be discovered. The Wenlock specimens differ also from the type *T. Chicagoensis*, which has a wide umbilicus exposing all the spiral system, though in the elongate character of its dorsal orifices it appears to be remarkably similar.

An analogy, at first sight, seems to exist between the British

[1] Murchison's Silurian System, 1839, pl. 8, fig. 1, pp. 616, 617.
[2] Murchison's Silurian System, 1839, pl. xii. figs. 23, 24, p. 627.

species and *T.* (?) *trigonostoma*, if we may judge from Hall and Whitfield's figure, which exhibits the discoid spiral region wedged in between the apertural lips, in other respects the American species differs in being deeply sinuate, and possessing no perforations.

In making an examination of the Silurian Gastropods in the Jermyn Street Museum, through the kindness of my former colleague, Mr. George Sharman, the Palæontologist, my attention was directed to three specimens, on a tablet numbered $\frac{8}{7}\frac{4}{8}$, from the Lower Ludlow of Mary Knoll, all of which were referred to *B. dilatatus*, though probably only one of them could with safety be referred to that species. One of these three specimens had a wide umbilical region, as well as some raised prominences on the central part of its dorsal surface, strongly suggestive of perforations, and in other respects the specimen appeared to closely resemble the genus *Trematonotus*.

EXPLANATION OF PLATE IX.

Fig. 1. *Trematonotus Britannicus*, R. B. Newton. Ventral view.
Fig. 2. Dorsal view of same specimen; the dotted outline indicates the extent of expansion which is hidden by matrix.
Fig. 3. Profile of same exhibiting the reflected lip and the raised perforations.
Fig. 4. Dorsal view of another specimen with fewer orifices.

The figures are drawn of the natural size.

II.—On certain Affinities Between the Devonian Rocks of South Devon and the Metamorphic Schists.

(Part III.)

By A. R. Hunt, M.A.

(*Concluded from page* 294.)

The Intensity of the Metamorphic Action.

In the Devonian sandstones and grits of Torbay abundant quartz veins are occasionally developed, indicating a moderate amount of heat. Neither the quartz-grains nor occasional fragments of felspar are to any extent affected.

At Dartmouth, on the raised-beach platform, quartz is largely developed together with a little felspar and chlorite, indicating sufficient heat to form or re-form these minerals. At Slapton Sands the grits are about the same as in Torbay: felspar granules remain angular and intact.

Between Beesands village and Tinsey Head the quartz-grains occasionally show signs of incipient solution, as also do the tourmalines. In one slide (No. 5) the approach of schistosity seems to be heralded by minute roughly parallel cracks cemented by iron ores and a pale-green mica.[1] Minute crystals of pyrites, some rectangular, are formed in the rock. At the Start, in rare cases, grains or remnants of grains of original granitic quartz can be detected in the schist.[2] Tourmaline is partially dissolved with recrystallization.[3] In the Bolt district no trace of original minerals has been detected even in the least altered of the schists. In the diabases the amount of alteration is irregular. Near Dartmouth we

[1] Plate 7, fig. 2. [2] Plate 7, fig. 1. [3] Plate 6, fig. 2.

meet with both ordinary fine-grained diabases, and diabases which have almost lost their original minerals by chemical processes. At Winslade quarry, in the same block, we note an ordinary diabase, and a chloritic rock whose augites are almost past detection. Near the Start we find a metamorphosed volcanic rock, apparently a plagioclase-pyroxene variety, which may well have been first altered by chemical action, and subsequently sheared and metamorphosed dynamically, with development of fibrous hornblende and zoisite.[1]

The evidence of the above rocks, from Torbay, and more especially from Dartmouth, westward, seems to indicate that the passage is from rocks affected by a high temperature and pressure, to rocks affected by a higher temperature and pressure, the one below and the other above the heat requisite for the ready solution of the quartzose, schorlaceous and felspathic components of the rocks involved; hydrothermal conditions being prevalent in each case.

The Character of the Metamorphosis.

Hydrothermal action would probably suffice to account for the passage of the micaceous sandstones into quartzites, and with pressure added, into quartz-schists; but simple hydrothermal action will not meet the case of the altered diabases. Even so far east as Dartmouth we find an uncrushed diabase at Sandquay with its original augite crystals nearly obliterated, and we know from the experiments of M. Daubree that augite is not affected by plain superheated water.[2]

The augite crystals of the South Devon diabases are often pierced by laths of felspars: felspar in decomposing would tend to produce silicate of aluminium—clay. According to Miller, "the intermixture of lime magnesia and oxide of iron with clay . . . causes it to be more readily attacked by acids."[3] In a decomposing crystal of augite pierced by felspar, we have the exact conditions for accelerating the action of acids, viz. the association of lime, magnesia, and iron with clay. In ordinary cases water, charged with carbonic acid by decomposing vegetation, percolating through the diabase, might in the presence of heat go far towards the production of secondary felspar, chlorite, and hornblende; but the complete metamorphosis undergone by the green schists seems to call for more active agents in the form of strongly acidulated mineral waters.

In the green schists of Bickerton and Rickham Sands, we have granules of felspar,[4] probably albite, embedded in a matrix consisting chiefly of chlorite, and in the former occasional epidote and carbonates.

In the diabases we have crystals of augite in a matrix of felspar, probably a lime-soda felspar. In the Southern rock we have a magnesian matrix, and in the Northern a non-magnesian matrix. For the passage of the Northern rock into the Southern, as repre-

[1] Appendix, slide 40.
[2] Geologie Experimentale, vol. i. p. 207.
[3] Elements of Chemistry, vol. ii. (third edition), p. 509.
[4] In these rocks there is often a marked alineation of the felspar.

sented at Bickerton, a large accession of magnesia is requisite; and for the carbonates a considerable amount of carbonic acid.

Hydro-thermal and dynamic action combined seem to meet the case, provided that the super-heated water be sea-water charged with carbonic acid. An instance of hot salt water, probably sea-water, giving rise to chlorite, brown hornblende, pale-green actinolite, and pyrites is recorded by the late Mr. J. A. Phillips in the case of the Huel Seton Mine.[1] Mr. Ussher has sent me a specimen of an acid eruptive rock, occurring within a mile and a half of the metamorphic area, whose quartzes are charged with fluid carbonic acid; so we have evidence of volcanic action, with abundance of carbonic acid, in the neighbourhood of the green rocks.

With magnesia and carbonic acid available from an outside source the process of metamorphism seems easy.

Starting with augite and lime-soda felspar, we have (leaving out silica which is common to all the original minerals concerned; and iron, which is common to all except felspar):—

$$\frac{\text{Magnesia, lime}}{\text{augite}} + \text{Alumina} = \frac{\text{Alumina, magnesia, lime}}{\text{hornblende.}}$$

$$\frac{\text{Alumina, magnesia, lime}}{\text{hornblende}} + \text{Carbonic acid} = \frac{\text{Alumina, magnesia}}{\text{chlorite}} + \frac{\text{Carbonic acid, lime}}{\text{calcite.}}$$

Again,

$$\frac{\text{Alumina, lime-soda}}{\text{felspar}} + \text{Carbonic acid} = \frac{\text{Alumina, soda}}{\text{albite}} + \frac{\text{Carbonic acid, lime}}{\text{calcite.}}$$

$$\frac{\text{Alumina, lime-soda}}{\text{felspar}} + \text{Carbonic acid} + \text{magnesia} =$$

$$\frac{\text{Alumina, lime, magnesia}}{\text{hornblende}} + \text{Albite} + \frac{\text{Alumina, magnesia}}{\text{chlorite}} + \text{Calcite.}$$

Thus carbonated sea-water acting on augite associated with a lime-soda felspar, supplies all the materials for the formation of the secondary materials, hornblende, chlorite, felspar and calcite, which form the mass of the Green Rocks.

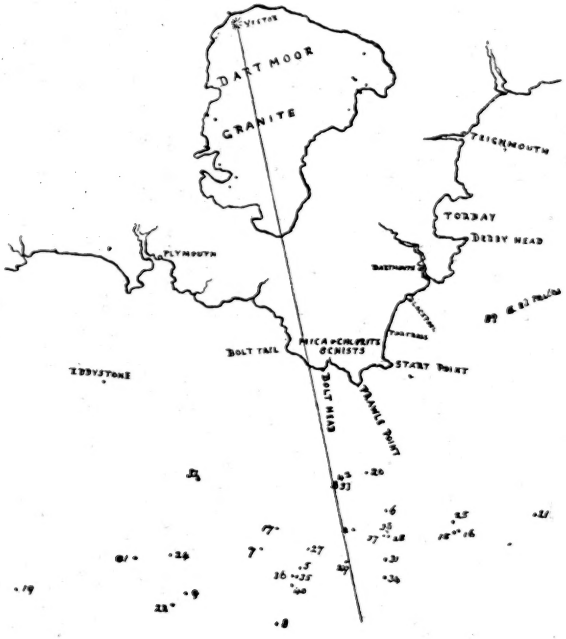
The epidote of the Green Rocks seems to be often associated with a water-clear felspar, entirely free from decomposition and possibly albite. The decomposition of a lime-soda felspar such as labradorite would account for the association of albite with epidote, *e.g.*

$$\frac{\text{Alumina-lime-soda}}{\text{Labradorite.}} = \frac{\text{Alumina-soda}}{\text{albite.}} + \frac{\text{Alumina-lime.}}{\text{epidote.}}$$

There seems weighty evidence in support of the hypothesis that the metamorphic rocks of S. Devon are Devonian, and of about the same age as the sandstones and slates with *Pleurodictyum problematicum* of the northern shore of Torbay; in which case the genesis of these Devonian schists should prove an attractive problem for chemists and petrologists. Should the schists however ultimately prove to have no connection with the Devonian rocks, the two together will surely afford an unparalleled example of undesigned coincidences.

[1] Phil. Mag. ser. 4, vol. xlvi. pp. 30, 31.

The annexed sketch chart of the positions of the crystalline trawled-blocks, prepared long since to compare the relations of these rocks with the granite of Dartmoor, brings out the curious fact that a line drawn from the highest land in Dartmoor into the English Channel, dividing the blocks equally, passes through the centre of the Bolt district. It also passes within about half a mile of Stolliford, North Bolbury, and South Down Farm, whence I have received respectively the most schist-like Devonian diabase, the most hornblendic of the granular Green Rocks, and the most altered of the quartz-schists, in my collection of slides.



Map showing relative positions of the Dartmoor Granite, the South Devon Schists, and blocks of Crystalline Rocks trawled in the English Channel.

It only remains for me to render my best thanks to those friends who with entire disinterestedness have assisted me from time to time by instruction and otherwise, in investigating the affinities between the altered and unaltered rocks of South Devon. Without the kindly and varied help of Messrs. Harker and Teall and of the late Mr. Tawney with the rock sections, and that of Messrs. Ussher and Somervail with the rocks themselves, the present paper could scarcely have been written. For all conclusions, and errors, I assume entire responsibility, whilst crediting my aforesaid friends

with being directly or indirectly the originators of whatever may be of value in the foregoing pages.

PARALLELISMS BETWEEN THE DEVONIAN AND METAMORPHIC ROCKS.

DEVONIANS.	METAMORPHIC ROCKS.
Micaceous sandstones } *Micaceous slates* }	*Micaceous quartz-schists* } *Mica-schists* }
Diabases } *Slates* }	*Green Rocks* } *Mica-schists* }
Micaceous grit-bands in slates	*Micaceous quartz-schist bands in mica-schist*
In *grit-bands*	In *quartz-schists*
Quartz-grains with negative crystals	Quartz-grains with negative crystals
Quartz-grains with hair-like inclusions	Quartz-grains with hair-like inclusions
Detrital tourmaline	Detrital tourmaline
Re-crystallized secondary tourmaline	Re-crystallized secondary tourmaline
White mica	White mica
Ferruginous laminæ with filmy mica	Streaks of iron with filmy mica
Pyrites crystallized in cubes and prisms	Pyrites crystallized in cubes and prisms[1]
Hæmatite cementing cracks.	Hæmatite cementing cracks
Black granules, magnetite (?)	Black granules, magnetite (?)
Diabase } *Schistose diabase* }	*Compact Green Rocks* } *Green schists* }
In *Diabase*	In *Green Rocks*
Secondary quartz	Secondary quartz
Compact hornblende	Compact hornblende
Fibrous hornblende	Fibrous hornblende
Felspar	Felspar
Epidote	Epidote
Two chlorites	Two chlorites
Iron ores	Iron ores
Veins in slates	*Veins in mica-schists.*
Felspar	Felspar
Quartz	Quartz
Chlorite	Chlorite

Calcite is abundant both in the Devonian and metamorphic rocks. No comparison has been attempted owing to the uncertainty of its origin.

In the spring of last year Mr. Harker was kind enough to examine eight specimens of the altered and unaltered rocks of South Devon, lettered in three series, as they seemed to me to invite comparison.

The following valuable notes were received by me on the 20th May, 1891, accompanied by permission to make any use of them. Although a far more complete set of rocks could now be selected for comparison, the following have the unique advantage of having been described at the outset of the investigation by a specialist, who, besides having no detailed information about the mode of occurrence of the specimens themselves, was not especially interested in the problem of the schists of South Devon.

[1] In siliceous band south of Hope Headland.

Appendix.

Notes by Alfred Harker, Esq., M.A.,

Fellow of St. John's College, Cambridge.

(26) A_1. *Sandquay Quarry.*

This is a much altered diabase, the original augite and felspar being almost totally destroyed. Here and there traces of a characteristic ophitic structure can be discerned; but there has also been a porphyritic development of larger crystals of felspar, and to a less extent of augite, as indeed is seen in the hand-specimen. Rare needles of apatite and grains of iron-ore are to be reckoned among the original constituents.

The most interesting feature is seen in the numerous little veins which traverse the slide, clearly representing cracks filled by secondary minerals. The clear material of these little veins seems to be in some places quartz, but most of it is felspar with evident twin-lamellation. This mineral has generally grown perpendicular to the walls of each vein, but where the cracks traverse porphyritic crystals of felspar, the new felspar substance is oriented in the same way as the old, with its twin-lamellæ parallel to the almost obliterated twinning of the original crystals. A considerable amount of pale fibrous amphibole is enclosed by the felspar and quartz of the veins, the fibres set perpendicularly to the walls of the vein in each case. Another mineral enclosed is a chloritic substance in vermicular growths.

The appearances in this rock do not demand any agency beyond those involved in the ordinary processes of 'weathering.' The secondary growth of felspar is now well known in rocks in which there is no reason to suspect any 'metamorphism' as ordinarily understood.

(31) A_2. *Combe Cross Quarry, Higher Fuge, West of Stoke Fleming.*

This rock is a diabase less decomposed than that of Sandquay. A considerable amount of fresh light-brown augite remains, and is seen to be penetrated by the lath-shaped sections of decomposed felspar in the ophitic fashion so characteristic of diabasic rocks. There is no porphyritic structure in this specimen. Iron-ores are rather abundant, and in reflected light the black ground is seen to be crossed by white or grey bars in the manner which has been supposed to indicate a parallel intergrowth of magnetite and ilmenite. As before, there are veinlets consisting of clear lamellated secondary felspar, and a rather fibrous amphibole. The latter is here better developed than in the preceding slide, and has a pale-greenish to brownish tint. Both minerals have grown perpendicularly to the walls of the little cracks. The pale secondary amphibole is also seen in places forming a narrow fringe to the augite plates, and showing the usual crystallographic orientation with respect to that mineral. This is a phenomenon met with in some districts which have been subjected to more or less mechanical stress,[1] but it cannot be urged as a *proof* of dynamic metamorphism.

(33) A_3. *Mill Hill Copse Quarry, Blackpool Valley.*

This is a schistose rock, precisely such as would result from the crushing of the diabase A_2. The schistosity, well seen in the hand-specimen, is marked in the slice by a general parallel arrangement of the constituents, and especially of those of secondary origin. The most abundant of these are a greenish-yellow mineral of the chlorite family and a pale amphibole. The latter has no longer the fibrous structure, but is compact, with evident hornblende-cleavage. Its absorption colours are pale bluish-green parallel to the γ-axis, and pale-brown perpendicular to that direction. The original ophitic structure of the diabase is preserved in certain little patches like 'eyes,' in which light-brown augite is seen, penetrated in the usual fashion by elongated crystals of felspar, mostly decomposed. A few felspars are still clear enough to show the twin-lamellation, and there are also relics of the original iron-ores, which are shown by the development of semi-opaque leucoxene to have been partly titaniferous. The augite, and to some extent the iron-ores, are traversed by fissures roughly perpendicular to the schistosity of the rock, a result of 'stretching'.

[1] *e.g.* Eastern Caernarvonshire: cf. Harker; Bala Volcanic Series of Caernarvonshire, pp. 83, 117; 1889.

in the direction of the schistose structure. Most of the chloritic mineral in the rock polarizes in fairly high tints, but a portion of it gives only low interference-colours. When this mineral occurs in association with the pale hornblende, it wraps round the latter in a streaky manner. A little quartz-vein which traversed the rock, has been contorted and broken in the process of crushing, and affords some measure of the amount of compression in the direction perpendicular to the schistosity.

(40) A_4. *Coast south of site of Start Signal House.*

This is a thoroughly metamorphosed rock. In its original state it has presumably been a diabase or some allied augitic type; but it is now converted into a mass of minerals newly crystallized *in situ*, and having the fresh appearance so characteristic of the crystalline schists. Original structures are completely obliterated.

There is abundance of the pale-greenish amphibole noticed above, partly in fibrous streaks and patches, partly in compact crystals, though usually with little indication of crystal-outlines. In a few places we notice crystals, bounded by the prism-faces alone, with no pinacoid, and with irregular terminations; but this is only when the amphibole is moulded by a certain pale scaly mineral, apparently one of the ripidolite group. The fibrous amphibole builds densely matted patches or occurs in isolated wisps enclosed in the felspar areas, and having a general parallelism with the rude schistosity of the rock as a whole.

Felspar occurs abundantly in aggregates of interlocking pellucid crystal-grains, rarely showing much indication of external crystal form. Twin-lamellation is very prevalent, and sections perpendicular to the lamellæ give extinction angles up to about 14°: this is not sufficient to distinguish between varieties of albite and andesine.

After the felspar and amphibole the most abundant constituents are epidote and zoisite. These form rather short columnar crystals, conspicuous, by their high refractive index, with indications of a longitudinal cleavage and a marked cross-jointing. The crystals give sensibly straight extinction. The two minerals are distinguished by the brilliant polarization of the epidote as contrasted with the low tints given by the zoisite. They occur in association with one another, and are moulded or enclosed by the other constituents of the rock. So far as our knowledge goes, epidote and zoisite are minerals characteristic of dynamic rather than thermal metamorphism in basic igneous rocks. The amphibole and felspar might well be formed in either case, but the rather coarse-grained aggregates of twinned felspars in this rock would, I believe, be difficult to match among products of "contact"-metamorphism.

(3) B_1. *Cliffs at North-east end of Slapton Sands.*

This is a reddish-brown, fine-grained, micaceous sandstone. As usual, the slice shows the little scales of colourless mica to be much less abundant than might be conjectured from the hand-specimen. They show an arrangement parallel to the bedding and are doubtless of detrital origin. The grains building the bulk of the rock are almost exclusively of quartz, in which both glass- and fluid-pores are detected. There is a ferruginous matrix separating the grains, and in places in sufficient quantity to show a well-marked lamination. An indication of "spectral polarization" in the quartz perhaps points to a certain degree of strain.

(4) C_1. *From the same Locality.*

This rock is very similar to the preceding, though with rather less of the ferruginous paste. An occasional grain of fresh lamellated felspar occurs among the quartz. The little mica-flakes are rare, but there are occasional rolled granules of tourmaline, both brown and blue. The quartz-grains enclose numerous fluid-pores, besides brownish inclusions apparently of glass, and an occasional little prism of zircon, etc. The rock has all the appearance of being derived from the destruction of a tourmaline-bearing granite.

(24) B_2. *North of site of Start Signal House.*[1]

This is a typical dynamo-metamorphic rock. The hand-specimen shows a schistose structure, accentuated by the development of a filmy secondary mica, and there are

[1] Plate 8, fig. 1.

also rather acute zig-zag contortions. Under the microscope the structures characteristic of mechanical metamorphism show more decidedly. The clear granular patches of quartz, etc., have the well-known form of lenticular streaks, and smaller patches of similar character occur like 'eyes' imbedded in inconstant bands composed largely of colourless mica, the micaceous films showing the usual wavy parallel arrangement and clinging round the enclosed 'eyes.' In some broader bands, also rich in mica, both colourless and yellow or brown, the structures, developed by a shearing movement of the mass, are seen in various stages. First a system of minute unsymmetrical parallel folds is produced, their axial planes inclined at an angle of about 45° to the general schistosity of the rock. These folds become compressed and pushed over until they pass into little reversed faults about $\frac{1}{200}$ inch apart. The faults are formed at an angle of about 30° with the general direction of schistosity, but by further movement they come to coincide more closely with that direction, and are finally lost in the parallelism of the micaceous streaks.

The clear granular patches in the slide consist, at least for the most part, of quartz. The intricate interlocking of the several grains proves that the whole has crystallized *in sitû*, and their imperfect extinction or 'spectral polarization' indicates a condition of internal strain. The rock may have been originally a shale or slate with some gritty bands. It compares very closely with the Skiddaw Slates, where they have undergone locally profound dynamic metamorphism, as at Brownber, in Westmoreland.[1]

(8) C_3. *South of Start Farm.*[2]

This is a type of rock which corresponds to what has sometimes been called a quartz-schist. The schistose character is but slightly marked in the hand-specimen. Minute scales of mica are arranged to give a parallel structure; but the mineral is only sparingly present.

Under the microscope the rock is seen to consist almost exclusively of clear grains of quartz of varying size and generally irregular shape. It is not clear that there has been any considerable recrystallization, and there is certainly nothing like the degree of metamorphism evidenced by specimen B_2. The few scattered flakes of colourless mica may be original. The slice is traversed by numerous little cracks cemented by opaque iron-ores. These are wavy and branching, but maintain a rough parallelism throughout the slice, agreeing in direction with the scales of mica.

III.—An Irish Augitite.

By Bernard Hobson, M.Sc., F.G.S.;
Assistant Lecturer in Geology at the Owens College, Manchester.

WHEN writing my paper "On the Igneous Rocks of the South of the Isle of Man,"[3] I was led to compare a Manx melaphyre, from Scarlet Point, with a rock described by Prof. E. Hull[4] as a melaphyre, occurring at Ballytrasna, near Limerick, and belonging to the "Upper Trap-band," a little below the basal shales of the Coal-measures. Through the kindness of Prof. Hull, a chip of the rock was sent to me by the Irish Geological Survey. The specimen was black and basaltic-looking. I did not obtain satisfactory sections of it in time for my paper, but have since had excellent ones made. On examining them I was immediately struck by the resemblance of the rock to the augitite of Paschkapole,[5] between Velmin and

[1] See paper by Prof. Nicholson and Mr. Marr, with Appendix; Quart. Journ. Geol. Soc. vol. xlvii. pp. 512-514 (1891). [2] Plate 71, fig.

[3] Quart. Journ. Geol. Soc. vol. xlvii. (1891), pp. 432–450 (reprinted with additions in Yn Lioar Manninagh, 1892, pp. 337–348).

[4] "On the Microscopic Structure of the Limerick Carboniferous Trap Rocks," Geol. Mag. 1873 (pp. 153–161), p. 157. Prof. Hull gives a list of papers relating to the geology of these rocks.

[5] Mentioned by H. Rosenbusch, Mikroskopische Physiographie der Massigen Gesteine (1887), p. 821.

Boreslau, in Bohemia, with a section of which I compared it. Professor Hull[1] describes the rock of Ballytrasna as containing "numerous large crystals and groups of banded felspar"; but I failed to find a single felspar in four sections, nor did I observe any in Allport's section, No. 1902,[2] from the same locality, which agrees with my sections. I submitted a section to Prof. H. Rosenbusch, of Heidelberg, from whose letter to me I translate: "Plagioclase I cannot find, it was most probably never present. In its early state the rock contained only augite and iron ores in two generations, a little biotite around the iron ores of the first generation, and probably a glassy base, which, however, I nowhere with certainty see preserved. On the contrary, it is changed to a chloritic substance, which is here and there speckled with brownish limonite." The structure of the rock is hypocrystalline porphyritic in Rosenbusch's[3] sense. The phenocrysts[4] consist of augite and magnetite, and perhaps biotite, if the inclusions of it seen in the augite phenocrysts are not due to crystallization of included ground-mass. The augite phenocrysts are idiomorphic and pinkish-brown in colour by transmitted light. Their maximum diameter is occasionally 2·9 mm., but more commonly 1·65 mm. or less. Twinning is rare. Zonal structure is common, so are magnetite and glass inclusions, the latter often altered to the chloritic substance before mentioned. The augite phenocrysts are themselves frequently partially or completely altered to a light-greenish serpentinous or chloritic alteration-product, and the pseudomorphs thus formed are often surrounded by interrupted patches of apparently secondary magnetite. Although the zonal structure defines the crystal faces with distinctness, yet the actual margins of the crystal sections are most frequently ragged or jagged and irregular, with magnetite crystals, or more rarely with augite crystals of the ground-mass, projecting into them. This irregularity of contour is well shown in fig. 19 (pl. xxxiv.) of Mr. S. Allport's paper.[5] I am inclined to regard it as due to the intratelluric augites continuing their growth during the period of effusion, rather than to a growth after consolidation of the rock.

The augite of the ground-mass occurs as very abundant idiomorphic crystals, mostly elongated in the direction of the vertical axis *c*. The average dimensions of the crystals are ·07 mm. × ·01 mm. They are faintly brownish in colour and are frequently twinned, the twinning plane being the orthopinacoid.

Magnetite is very abundant. It occurs as phenocrysts, often included in the porphyritic augites, as before mentioned, and is frequently idiomorphic, though in some cases the crystalline form

[1] *Loc. cit.* p. 157.

[2] In the British Museum (Natural History).

[3] *Op. cit.* pp. 339–340.

[4] Term proposed by J. P. Iddings, "On the Crystallization of Igneous Rocks," Phil. Soc. Washington Bulletin, vol. xi. (1889), p. 73, for "porphyritic constituents" in Rosenbusch's sense.

[5] On the Microscopic Structure and Composition of British Carboniferous Dolerites, Quart. Journ. Geol. Soc. vol. xxx. (1874), pp. 529–567.

cannot be made out with certainty. It is also abundant in the ground-mass. Not unfrequently it is partially altered to yellowish brown limonite.

Biotite is present in only small quantity. Its pleochroism is, for rays vibrating parallel to the cleavage cracks, golden yellowish brown, for those at right angles to that direction faint yellowish brown. It not merely surrounds the magnetite of the first generation but appears to have crystallized after the augite crystals of the ground-mass, as the mica is allotriomorphic to them; in short they project into it as the felspars do into augite in ophitic structure.

The chloritic substance above mentioned by Rosenbusch, as probably replacing an original glassy base, is present in considerable quantity. It occupies more or less isolated angular spaces between, or surrounds all the crystalline constituents.

As the result of a somewhat hasty examination at the British Museum (Natural History) of Mr. Allport's section, No. 1900, of trap (from the Upper Trap band) of Rathjordan,[1] I found it to agree with that from Ballytrasna[2] in most respects, though I had not time to make certain whether phenocrysts of olivine were originally present, as both Allport and Hull[3] agree in stating. If so, it would be a limburgite. I take the "cells" mentioned by Prof. Hull, as occurring in the glassy base of the Ballytrasna rock, and the "tubes and cells" described and figured by him (pl. viii. fig. 9) from the Rathjordan rock to be really augite crystals of the ground-mass. That there is no improbability in limburgites (and augitites) being present among the Limerick traps is shown by a remark of Sir A. Geikie,[4] who states (apparently on the authority of Mr. W. W. Watts) that the upper basalts of Nicker Hill[5] contain "only 38·66 per cent. of silica" "thus approaching the limburgites."

As most of the traps from the Limerick district contain plagioclase there can be little doubt that the Ballytrasna rock is a basaltoid[6] augitite. It is probably more basic than the basalt of the Lion's Haunch, Arthur's Seat, Edinburgh, and than the Manx melaphyre with which I was led by Prof. Hull's description to compare it. So far as I know, the Ballytrasna augitite (I use the term regardless of geological age) is the first which has been described as occurring in the British Isles.

[1] Described by Allport, *loc. cit.* p. 552.

[2] Ballytrasna must be a very small place, as it is not marked on the One-inch Geol. Survey Map (sheet 154). I understand that it is about two miles east of Rathjordan.

[3] *Loc. cit.* p. 157.

[4] Anniversary Address to Geological Society, 1892; Proceedings p. 147 (p. 123 of separate copies).

[5] One-inch Geol. Survey Map, sheet 144 and Explanation, p. 31.

[6] H. Rosenbusch, Ueber die chemischen Beziehungen der Eruptivgesteine. Tschermak's Mineral. and Petrog. Mittheilungen, vol. xi. (1889) p. 158.

IV.—Underclays: A Preliminary Study.

By G. W. Bulman, M.A., B.Sc.;
Corbridge-on-Tyne.

SINCE the advent, in 1840, of Sir Wm. Logan's paper "On the Characters of the Beds of Clay immediately below the Coal Seams of South Wales," underclays have generally been regarded as representing the soils on which grew the vegetation now forming the coal. I am not aware, however, that any definite and detailed hypothesis has been put forward to account for their origin. The superior interest attaching to the question of the origin of coal has apparently overshadowed the less important underclay, and it has been left to fit itself in with any particular hypothesis of the former which happened to be in favour. At the same time, two general views of its origin have been suggested which do not, however, go into any detail as to the exact manner in which it has been brought about. First, there is the opinion that underclays are terrestrial accumulations, thus expressed by the authors of the "Geology of the Yorkshire Coal-field":

"There can be no doubt then that the underclays are old vegetable soils, and that, unlike all the Carboniferous rocks we have hitherto noticed, they were formed not under water, but on dry land" (p. 19).

Prof. Hull, on the other hand, in his "Coal-fields of Britain," expresses the opinion that underclays were laid down in water:

"Now these underclays are distinctly stratified, showing that they have been deposited under water" (pp. 66–7).

Sir A. Geikie expresses a similar opinion in the following passage from his "Text Book of Geology," and further indicates that they were laid down in the *shallowing* water, just before it became a marsh and was taken possession of by vegetation:

"Where the clay was laid down under suitable circumstances, vegetation sprang up upon it. This appears to have taken place in wide shallow lagoon-like expansions of the sea, bordering land clothed with dense vegetation" (p. 477).

With regard to the first of these views it almost seems to be implied that the underclay was formed in the same way as a modern vegetable soil. But this interpretation may be dismissed at once, for the underclay, although it may well have played the rôle of foundation to the marsh, and received the roots of the vegetation, is not in the least like a vegetable soil, for a modern vegetable soil is formed of vegetable matter mingled with disintegrated rock, and passes by gradual transitions through the subsoil to the rock below. An underclay, on the other hand, is obviously an independent formation, and not formed by disintegration *in situ* of the rock below, from which it is separated by clear lines of demarcation.

The chief indictment against both these views of the origin of underclay is, that no example of the formation of clays at the present day, either on land or in very shallow water, has been brought forward. In fact, all we know about such fine grained deposits as clay leads us to attribute them—as a general rule, with

a few exceptions—to quiet and deepish waters. Thus the formation of clay is described as follows in Phillip's "Manual of Geology":

"The carbonic acid, which is always dissolved in water, attacks the felspar by dissolving out from it carbonates of potash, soda, or lime; and then the crystals lose their hardness and become changed into a paste of impalpable fine particles which form a mud. This mud is held in suspension longer than the sand, and is therefore carried further out to sea. When it falls to the bottom and is compressed by the weight of the water above, it becomes clay, and margins or surrounds the land as an outer belt, probably twice as broad as the sand belt. On some coasts, like the South American coast mentioned by Mr. Darwin, there may be no clay deposited within one hundred and fifty miles of land" (vol. i. p. 50).

Sir Charles Lyell, again, describes the deposition of clay as taking place in the deeper portions of Lake Superior. And one of the results of the "Challenger" expedition has been to show that oceanic deposits in depths greater than 2000 fathoms are clays. But satisfactory cases of deposits at all analogous to underclays being laid down in a shallowing area just before vegetation commences to grow in the present order of things do not seem to be forthcoming. And if underclays were so deposited why are they not laminated?

That the geological study of clays is behind that of other rocks, while satisfactory evidence from causes now in operation is not forthcoming, seems to be indicated in the following quotation from Phillip's Manual (part i. ed. 1885):

"No such careful and detailed examination has been made of existing mud and clay as of sand or limestone. The subject is much more difficult . . . . and the observations on deposits now forming are too few to completely demonstrate the conditions under which many of the newer clay beds were formed."

In the following description by Prof. Green of the formation of coal there is no room left for the deposit of the underclay:

"But the downward movement was not without intermission; every now and then a pause occurred, and whenever this happened the water would tend to be filled up. Sand-banks formed shoals, which by degrees grew into islands: the channels between the islands were gradually choked up with sediment, till at last the whole or portions of the lake became replaced by swampy plains or morasses, across which sluggish rivers slowly wound their way. Vegetation spread from the adjoining land over the marshy flats, and under the moist and otherwise favourable conditions grew apace, till the whole became converted into a rank and tangled jungle" (Coal, its History and Uses, pp. 56–7).

According to this view the coal is evidently formed on a sand-bank.

The analogy of modern peat bogs, which are generally found to be underlaid by some sort of clay, is sometimes strongly insisted upon in connection with underclays; and yet, on examination, it appears that many of our peat bogs rest on clays belonging to a different geological age—as on the Boulder-clay, or on the clays of the Coal-measures themselves—and so do not admit of comparison

with the Coal-seam and its underclay. Those peat mosses, again, which form the most recent layer in the filling up of lakes do not require that the substratum should be universally an impervious clay; for the same causes which led to the formation of the lake in the first instance will prevent the drainage of the filled up area.

Sir Charles Lyell, indeed, in describing lake deposits in general, gives *shell-marl* as the stratum immediately below the peat, thus:

"If we drain a lake which has been fed by a small stream, we frequently find at the bottom a series of deposits, disposed with considerable regularity, one above the other; the uppermost, perhaps, may be a stratum of peat, next below a more dense and solid variety of the same material; still lower a bed of shell-marl, alternating with peat or sand, and then other beds of marl, divided by layers of clay" (Elements of Geology, p. 3).

And in the Meadows, Edinburgh, formerly the Borough Loch, the following section was met with in digging a drain, and is thus mentioned in the Survey Memoir of the Geology of the Neighbourhood of Edinburgh:

"A bed of lake-peat, from a few inches to upwards of a foot in thickness, was found immediately below the soil. A thin lay of marl, with the common freshwater shells, underlaid the peat and rested on silt, sand, or fine gravel, below which came the Boulder-clay."

In the Survey Memoir of the Geology of East Lothian two similar cases of peat immediately underlaid by marl are mentioned (pp. 67, 68).

According to Prof. Heer, again, the ground for the growth of peat as the final deposit in the silting up of a lake is due to Mollusca, and is thus described:

"The formation of an impermeable ground is the work of small mollusca, which live in the water in great abundance. After death their shells decompose, and gradually produce, with the inorganic deposits of the water, a sort of calcareous loam, called *blanc-fond* (white ground) in Neuchatel, and *lake-chalk* in the canton of Zug" (Heer's Primæval World of Switzerland, Heywood, vol. i. p. 24).

Clearly, then, the origin of underclays cannot be explained by the causes now in operation in the filling up of lakes.

As regards the occurrence of peat otherwise than as a lacustrine deposit, some interesting details are given in the Survey Memoir of the Geology of the South-west part of Lincolnshire. Several beds of peat at different levels and interstratified with clay, silt, sand, etc., occur. The following sections may be taken as examples:

		FEET.
(1).	Brown silty soil	1
	Reddish brown silt	1 to 4
	Blue clay	1
	Drab-coloured sandy clay	4 to 6
	Peat and peaty-clay	1
	Blue clay with marine shells	6
	Blue clay with peaty matter and wood at bottom	16
	Peat black and compact	1
	Coarse angular sand	1
	Bluish Boulder-clay, touched	1

(Brickyard one mile N.N.W. of Spalding. p. 107.)

		FEET
(2).	Brown silt	3
	Black peat	0½
	Sandy silt and loam with marine shells ...	5
	Yellowish clay	2
	Grey peaty clay	3
	Soft, clean, blue clay	2
	Peaty layer with drift wood and hazel nuts ...	0½
	Gravelly clay (? Boulder-clay) touched ...	

(Pit two furlongs East of Doveham. p. 108.)

(3).	Peat	1
	Clay with Marine shells	6
	Silt, sandy	3
	Peat with trees	2½
	Gravel...	10?

(Tattershall Brickyard at Dogdyke near mouth of River Bain. p. 111.)

The view advocated in the above memoir is that these deposits are the result of the silting up of a bay, and that they are marine deposits. The layers of peat occurring at various levels are held to be indications of old land surfaces. If this is so we must suppose there has been a filling up of the bay followed by a depression after its growth, for each bed of peat. Of such earth movements in the area under consideration there appears to be no independent proof, or we should have here a valuable illustration of the modern view of the origin of coal *in situ* with slow and intermittent subsidence. But some of the sections indicate rather a drift origin for some of the lower layers of peat. Thus in section (1) the peat rests on *coarse angular sand*, and in (3) on *gravel*, neither of which seems a likely substratum for a peat moss to flourish on. In (2), again, the layer of peat itself contains "drift wood" which is strongly suggestive of a *drift* origin for the peat itself.

The *clay beneath* the peat also frequently contains *marine shells*, which have apparently never been found in the underclays of the Carboniferous. On the whole, then, it does not seem that the beds commonly found beneath layers of peat throw much light on the origin of Carboniferous underclays. Yet the occurrence of such fine-grained deposits as these clays, as the final member of the series in the silting up of an area, and just before the growth of vegetation, is a valuable suggestion as to how an underclay might, under certain conditions, be formed in a shallowing area, and in immediate proximity to land.

The conditions in the Fen district are, however, somewhat peculiar, for the clays are *marine* deposits, and must have been brought by currents from considerable distances.

It has been asserted that *Stigmaria* are of universal occurrence in underclays. Thus Professor Green writes of them, "They always contain a peculiar vegetable fossil known as *Stigmaria*" (Physical Geology, p. 258).

And this—on the hypothesis that *Stigmaria* are the roots of the vegetation which forms the coal—is one of the strongest arguments that the underclays are old soils. But it is to be observed that while *Stigmaria* appear to be of almost—if not quite—universal occurrence in underclays, they are also often found in sandstones,

even when these are entirely distinct and separate from Coal-seams. Thus examples of sandstone with Stigmarian roots, and separated from Coal-seams by beds of underclay, occur in the following sections from the Survey Memoir of the Yorkshire Coal-field:

		FT.	IN.	
(1).	Coal	0	3	
	Underclay	1	1	
	Sandstone with Stigmaria rootlets	2	0	(p. 634.)
(2).	Coal	1	3	
	Underclay			
	Sandstone with Stigmaria rootlets.			

And examples of *Stigmaria* in limestone are not unknown. Thus they are found abundantly in the well-known Burdie House limestone of the Lower Carboniferous of Scotland.

Supposing that in all three cases, in the underclay, in sandstone, and in limestone, the *Stigmaria* are *in sitû*, it is a little curious that a plant which habitually grew in a swamp caused by an impervious stratum of underclay should flourish equally well on a sandbank or on a calcareous mud. It may, however, be suggested in explanation that the *Stigmaria* roots represent more than one type, and were not all marsh plants. And to suppose that *Stigmaria* in sandstone are usually *in situ* is to increase the necessary number of old land surfaces preserved in the Carboniferous period, already a serious difficulty, reckoning Coal-seams and underclays alone.

As regards the question of the position of *Stigmaria* in sitû, and their connection with the stems of the Carboniferous trees, it is to be noted that the most striking examples that have been brought forward are not in underclay but in sandstone. Thus the well-known case quoted and figured by Prestwich (Geology, vol. ii. p. 109), is in a sandstone. Moreover, the figure gives, on the whole, rather the impression of drift than growth, *in sitû*. And in that remarkable fossil forest near Sheffield, described by Dr. Sorby (Q.J.G.S., August, 1875), the roots of the trees ramify through a soft shaly clay, while the stumps are enveloped in a bed of sandstone. In the South Joggins section, too, and in the Cape Breton Coalfield, the more striking examples of stems with Stigmarian roots are found in the shale above the Coal-seams.

The occurrence of erect tree-stumps in connection with Coal-seams is certainly suggestive that the underclays have played the part of soils. And yet the very fact of the publication of papers "On *an* erect tree in connection with a Coal-seam," etc., seems to mark the rarity of the occurrence. But *if* the underclay really *was* the soil upon which was formed the coal by the growth of the Carboniferous forest, afterwards lowered beneath the water and enveloped in shale or sandstone, should we not expect such erect tree-stumps to stand as thickly as the trees in a modern forest?

But although the occurrence of erect tree-stumps is rarer than might be expected, Sir Charles Lyell mentions a portion of the South Joggins section, containing nineteen Coal-seams in which he observed *seventeen* trees at right angles to the planes of stratification.

Of these he remarks: "In *no* instance could I detect *any trunk intersecting* a layer of coal, however thin; and *most* of the trees terminated downwards in seams of coal" (Elements of Geology, p. 391).

Yet had the underclay been really the ancient soil we might reasonably expect to find the trees extending downwards to it.

This south Joggins section is described in more detail by Sir J. W. Dawson (Acadian Geology, chap. xl.). In glancing through the details of the beds there given it is observable that *the greater number* of erect trees are in the *roofs* of the Coal-seams. The *erect* position of such trees is generally supposed to indicate that they are in their original position of growth. M. Fayol, however, has pointed out that in the Coal-fields of Central France a certain number of stumps of trees occur at right angles to the planes of bedding, although a larger number are horizontal, or inclined at various angles; and yet he has, I think, conclusively shown that the coal of this district is of drift origin. Hence we must admit that the occurrence of a *few* erect trees is in itself no sufficient evidence that they are in the position of growth.

Dr. Croll has pointed out the almost entire absence of old land surfaces throughout the geological series except the coal and underclays of the Carboniferous. The familiar "Dirt bed" of the Isle of Portland is one of the few exceptions. We must also except the Coal seams of the Yorkshire Oolite of which Sir A. Ramsay has said that they "have not been formed of drift vegetation, for underneath each bed there occurs an *underclay*, or old soil, charged with the roots of those plants the decay of which on the spot formed the thin beds of coal" (Physical Geology of Great Britain, pp. 194–5).

And Sir J. W. Dawson writing of the strata of the Erian (= Devonian) system of America, states that they "include fossil soils of the nature of underclays, in which little else appears to have grown than a dense herbage of *Psilophyton*, along with plants of the genus *Arthrostigma*" (Geological History of Plants, p. 105).

If, then, we accept the belief that the underclays of the Carboniferous are old land surfaces we are forced to the conclusion that the physical conditions of that period have been unique—at least as far as regards Europe. Perhaps, however, this conclusion is inevitable in whatever light we regard the underclays.

Sir Wm. Logan considered it a universal rule in the South Wales Coal-field that a bed of coal reposed on an underclay, and the generalisation has been extended to all our Coal-fields. But there are exceptions, and coal is found at times resting on ordinary sandstone or shale. And underclays without any Coal-seams resting upon them are of common occurrence. Thus in the South Joggins section of 14,570 feet in thickness there are said to be 76 coal seams and 90 stigmarian underclays; so that at least 14 of these latter are without accompanying coal. Indeed, according to Sir J. W. Dawson's method of interpretation there are something like 238 old land surfaces in this remarkable section, and he notes that "the forest soils are much more frequently preserved than the forests themselves" (Acadian Geology, p. 186).

Interesting examples of the independent occurrence of coal and underclay are also met with in the Carboniferous rocks of Scotland, where in not a few cases they are separated by beds of sandstone. The following sections from the Survey Memoir of the Geology of Edinburgh (32 Scotland, 1861) may be taken as examples:

(1).

	FT.	IN.
Coal	0	3
Sandstone	3	0
Fireclay	23	0
Coal	1	5
Fireclay	9	0
Argillaceous shale ...	15	0
Coal	0	6
Sandstone	4	0
Fireclay	10	0

(p. 100.)

(2).

	FT.	IN.
Coal	2	0
Fireclay	4	0
Coal	2	0
Sandstone and shale	45	0
Fireclay	18	0

(p. 106.)

Underclays thus occurring without coal are accounted for by Sir Henry de la Beche as follows (Memoir, South Staffordshire Coal-field, p. 338):

"As will be readily understood, even all traces of a coal above a *Stigmaria* bed may be absent, either from the carbonaceous matter having been removed by the stream or current of water which deposited new matter, such as sand, above it, or from the conditions not having been so far advanced as to permit the *Stigmaria* bed or soil to be coated over with such carbonaceous matter."

But denudation by streams of Carboniferous vegetation can scarcely have been sufficiently uniform over large areas to account for the entire absence of coal over Stigmarian clays; such denudation would rather cut channels and hollows in the coal. It would, moreover, have left marks of denudation in the underlying clay.

And even in those cases in South Wales—mentioned in a note on the same page of the Memoir—where the carbonaceous matter has been "entirely removed, and even channels cut in the supporting *Stigmaria* beds," it is difficult to believe that the deposit of vegetable matter could disappear so entirely and leave no trace of its presence. Sir H. de la Beche speaks of the erosion having taken place when the coal was "unconsolidated"; but the carrying away of a dense mass of vegetation firmly rooted in clay would require currents of considerable force. Still there is no difficulty in understanding denudation cutting channels in the coal—like the "Horse" in the Forest of Dean—but denudation which will neatly slice off a layer of coal from its supporting underclay is another matter.

Other cases occur in which the same seam of coal rests partly on an underclay, and partly on sandstone. The following three examples are from the Memoir of the South Staffordshire Coal-field:

(1) "There is often above it a bed of fireclay or clunch a few feet in thickness, supporting the sulphur coal, but that is frequently absent, and the coal rests directly on the rock" [a sandstone, known as the New Mine Coal rock] (p. 195).

(2) "The upper measure is generally fire-clay or clunch, supporting the fireclay coal, and varying in thickness from 2 to 10 feet. This, however, is sometimes wanting, and the fire-clay coal rests directly on a 'strong rock' or hard sandstone" (p. 203).

(3) "The Bottom coal usually rests on a bed of fire-clay some feet in thickness. In many instances, however, this is wanting, and the coal rests on hard sandstone, the change from one material to the other being sometimes very abrupt" (p. 209).

And underclay is at times so associated with sandstone as to suggest for it a similar origin as to place and manner. For example, in the Survey Memoir of the Yorkshire Coal-field we have the following section:

	FT.	IN.
Coal	0	9
Underclay with bands of sandstone	3	4
Black shale	0	1
Underclay	1	8

On the other hand underclay may be *mixed* with sandstone, as in the case of a white sandstone 3 ft. 6 in. thick, met with in a boring at Seaton Carew (Durham), and separated from a coal-seam above by 4 in. of dark-blue shale (Notes on the Seaton Carew Boring. J. W. Bird. Nov. 8th, 1888).

And in whatever place and manner underclays were formed, vegetable matter—probably drift—must in some cases have had access. For fragmentary masses of coal—in the form of strings and veins—are at times found in it, as in the following section from the Survey Memoir of the Yorkshire Coal-field:

	FT.	IN.	
Coal	3	6	
Uunderclay and Coal-veins	0	8	
Sandy underclay	1	6	
Sandy shale	1	9	
Sandstone	2	0	
Underclay and Coal-veins	4	1	
Underclay	2	0	(p. 519).

It is difficult to draw any distinction as to mode of origin between such cases and those in which the coal appears to play the *rôle* of "partings" in a seam of underclay, as in the following section:

	FT.	IN.
Coal	0	6
Underclay	4	1
Coal	0	1½
Underclay	2	2
Coal	0	4
Underclay	1	5
Coal	0	3

(Survey Memoirs, Yorkshire Coal-field, p. 167).

From this we pass naturally to the case of a Coal-seam in which the underclay partings attain the same thickness as the intervening coal, as in the following section of a portion of the "Fire-clay" coal of the South Staffordshire Coal-field:

	FT.	IN.
Little coal	1	6
Fire-clay	1	6
Coal	0	7
Fire-clay	2	5
Coal	2	7

(Survey Memoir, p. 202).

And from this to an ordinary Coal-seam with "partings" of underclay, as in the following section of the Beeston Bed Coal, is but a step:

	FT.	IN.
Coal	2	0
Underclay	0	3
Coal	1	3
Underclay	0	5
Coal	0	5
Underclay	1	6
Coal	0	6
Underclay	0	2
Coal	0	2
Underclay	0	7
Coal	0	2
Underclay	0	2
Coal	1	8½

(Survey Memoir. Yorkshire Coal-field, p. 192).

Are we to look upon each "parting" of underclay as a separate soil and the foundation of a distinct marsh? And if so, ought we not also to consider all ordinary "partings" of a shaly, slaty, or clayey nature? It is a little difficult to understand, granting the formation of the underclay, how a stratum of clay two or three inches thick, could support the large trees which formed the greater part of the Carboniferous forests; and the earth movements required in the case of the above seam, supposing the underclay to be formed in shallow water and the coal on land, would be as follows:

After the formation of the lower 1 ft. 8½ in. of coal, there must have been a sinking of the land to the extent of two inches beyond the thickness of the bed of vegetable matter. This must have been followed by a pause of sufficient length to allow of the accumulation of two inches of underclay in the shallow water and the growth upon it of sufficient vegetable matter to form two inches of coal. This must have been followed by a submergence of this coal to the depth of seven inches, and a pause long enough for the deposition of seven inches of underclay and the growth upon it of two inches of coal. And so on to the top of the section. It is questionable whether we are justified in calling in such a system of earth-movements.

Finally it must be observed that a fine-grained deposit such as underclay is what we should expect to find beneath the coal on some such hypothesis of its drift origin as that of Mr. Goodchild (Geological Magazine, July, 1889). For in a gradually sinking area the zone of deposition of sandstone and shale would gradually give place to that of clay and vegetable matter. Again, the want of lamination, which is such a striking feature of underclays in general, would be a *probable consequence* of deposition in deep, quiet water, far from land, since the supply of fine sediment would remain so long suspended that its settling down would be likely to be uninterrupted and almost uniform.

There are two ways in which lamination may be produced:

(1) By flat plates of mica, which settle down more slowly than the sand and mud, but in the same zone of sedimentation, and

thus forming separate layers, cause the latter to split up when consolidated.

(2) By the *periodical supply* of sediment—as by floods occurring at intervals—so that one layer gets settled down and partially solidified before the arrival of the next supply.

Both causes of lamination are absent in the deep sea zone of deposition; the particles of mica are too small, and the supply of sediment too continuous.

And the nature of the beds immediately associated with underclays is at times suggestive of a deepish water origin. Thus we frequently find a sandstone succeeded in ascending order by a shale, next to which comes an underclay, upon which rests a bed of coal, as in the following examples from the Yorkshire Coal-field:

		FT.	IN.
(1)	Haigh Moor Coal { Coal	2	3
	Dirt	0	$0\frac{1}{4}$
	Coal	1	7
	Underclay and ironstone nodules	9	0
	Soft black shale	0	10
	Shale and ironstone	5	0
	Sandy shale and sandstone	4	0

(Survey Memoirs, p. 714.)

		FT.	IN.
(2)	Coal	1	0
	Underclay	0	7
	Shale and ironstone nodules	3	0
	Sandstone	1	3

(Survey Memoirs, p. 712.)

And a glance through the sections given in the above Memoir shows that such an order of succession is exceedingly common—it may, indeed, almost be said to be typical—while those above the coal show not infrequently an inverse order, as in a portion of the Seaton Carew boring given below:

	FT.	IN.
Grey sandstone	4	0
Dark-grey sandy shale	0	7
Coal	0	10
Dark-brown fire-clay	1	2
Dark-brown sandy shale	2	8
Dark-grey sandy shale	1	8
White sandstone	26	8

The obvious and usual interpretation of such a succession beneath the underclay would be a change from the shallow-water sandstone conditions, through the deeper zone of shale to still deeper where the fine-grained underclay was laid down. Above the coal, again, the natural interpretation would be shallowing water. And the following section from the Lower Carboniferous of East Lothian is instructive:

Limestone 10 feet.
Seam of coal, 10 inches, and *fire-clay* under.
Shale.
White limestone.

(Survey Memoirs, East Lothian, p. 54.)

The lower limestone contains marine fossils: *Productus* sp., *Athyris ambigua, Rhynchonella pleurodon, Lithostrotion junceum,* and *L. irregu-*

lare. And the upper, which rests immediately on the coal, contains: *Rhynchonella pleurodon*, var., *Fenestella plebeia*, *Encrinites*, etc. Here the interpretation of conditions would naturally be deepish water for the lower limestone, a change to shallower for the shale, and *after* the deposition of the underclay and coal a return to such deepish water for the upper limestone.

V.—On the Occurrence of a Black Limestone in the Strata of the Maltese Islands.

By John H. Cooke, F.G.S., etc.

WHILE engaged in the examination of the superficial deposits of the Maltese Islands, I have often met with rounded pebbles and angular fragments of a black, crystalline limestone, either lying on the rock surfaces, or embedded in the Quaternary formations.

The late Professor Leith Adams drew attention to the same fact as long ago as 1867, and in a paper which was published in the Quart. Journ. Geol. Soc. he expressed an opinion that the fragments which he had seen lying on the surfaces of the sides and summits of the Gozitan Hills, belonged to a formation that was of a much later age than any of the rocks that are now to be found *in situ* in the islands.[1]

Dr. John Murray, too, notes in his *brochure*[2] on the Maltese Islands the occurrence of similar fragments in the neighbourhood of Marsa Scirocco, and he further adds that no evidences of the rock having been found *in situ* in the islands had hitherto been recorded. The remarks of these gentlemen led me to consider the matter attentively, and I have, during the last year, been carrying on investigations with the object of discovering the origin of the black marble, the result of which has been to show that it is but a variety of the Lower Coralline Limestone, the basement bed of the Maltese series, and that it occurs extensively *in situ* in that formation. In the eastern and south-eastern parts of Malta considerable quantities of rounded boulders and angular fragments of black limestone, that vary in size from a walnut to a medium-sized pumpkin occur in the beds of the gorges, in the soil of the fields, and in all those localities where the Globigerina limestone has been eroded away, and the underlying basement rock has been exposed to view.

In the Quaternary strata, too, of both Malta and Gozo these fragments are especially numerous. The elephant bed in the Benhisa Creek at the south-eastern extremity of Malta affords a characteristic example of their mode of occurrence in the diluvial beds of the island.

In this bed large water-worn boulders, having, when broken, a

[1] Dr. Adams says, "Indications of more recent beds are seen in the blocks of weathered limestone known as Gozo marble which are seen strewing the valley eastward of the lighthouse on the northern shore, and in fragments of a black limestone or marble which strew the sides and summits of the Gozo Hills. There can, I believe, be no doubt that these fragments have no connexion whatever with any of the recent formations in the islands."

[2] "The Maltese Islands, with special reference to their Geological Structure," Scottish Geol. Mag. September, 1890.

jet-black lustre, occur at different depths intermixed with boulders and fragments of other colours, eighty per cent. of which are at once recognizable as having been derived from the formation out of which the creek has been formed. They generally lie with their longer axes in a horizontal direction, forming well-defined layers of several feet in thickness, alternating with beds of a rich red soil, containing the remains of several extinct species of elephants.

It was to this part of the island that I first directed my attention in my search for the origin of the bed from whence these boulders and pebbles had been derived, as, owing to the great amount of denudation to which the country around had been subjected, the whole of the beds, that had formerly overlain the basement rock, had been completely swept away, and the Lower Coralline Limestone had been laid bare over an area of several square miles in extent. The first evidence of the black limestone occurring *in situ* appeared on the road between Benhisa and Uied el Mista. The exact spot is situated directly opposite to Il Mara, at a distance of about 400 yards from the sea cliffs. It consists of a patch of black crystalline marble, which is similar in every respect to the limestone of which the boulders and pebbles are composed. The patch extends half-way across the road, and on the off side a cart-rut has been formed in it to a depth of eight inches. It occurs in division *b* of the Lower Coralline Limestone, but as no sections were in the vicinity it was not possible to determine its thickness. Judging, however, from a fragment which I detached at the bottom of the rut, and which showed a gradual transition of the black into the characteristic yellow variety of the formation, it is not probable that it is more than a foot. I broke off several pieces and made sections of them, as well as of several of the pebbles from the Benhisa Creek, which is not more than a mile away.

An examination under the microscope showed the specimens from both localities to have a granular texture, with here and there numerous well defined patches of calcite having a semi-radiated structure.

The insoluble residue that resulted after treatment with hydrochloric acid was chiefly composed of siliceous particles, and of flocculent, carbonaceous matter which remained in suspension in the solution for some considerable time. Both were hard, compact, and crystalline; and chemical analysis revealed the presence of sulphide of iron. The specimens were evidently identical. About one mile from this spot, and situated about 200 yards to the west of Ghar Hasan's Cave on the same coast, there is another patch or vein, which is similar in every respect to that to which reference has just been made. It occurs on the cliff edge, and at the western extremity of the first wall which is met with after leaving the cave. It is but small, having a diameter of four feet only, and as it does not abut on the cliff face its thickness was not shown.

Neither of the patches were of any great extent, and would not of themselves be sufficient to account for the quantities of blocks and fragments that lie scattered over the rock surfaces in their vicinity. It is probable that they are the remnants of the patches

and veins that formerly occurred in those portions of the Lower Coralline Limestone that were broken up when the upper deposits of the district were swept away. As I shall afterwards show when describing the occurrence of similar veins in the Gozitan beds, this black crystalline variety of the basement rock is still very common in the upper layers of that formation. In the Malta district to which I have just been referring these upper layers have been completely swept away, and nearly all traces of black veins have thus been obliterated.

In Gozo its mode of occurrence may be studied to the best advantage in the Lower Limestone quarries that are situated on the southern coast in close proximity to the church of the Madonna della Kala, and immediately opposite the islet of Comino. Fragments of a red as well as of a black variety are strewn around the hillsides in great number, while quantities of red and of black chippings are to be found intermixed with the debris of the quarry.

The sections that the quarrymen have cut, show that both varieties occur in thin irregular veins of from one foot to three feet in thickness, and from ten to twelve feet in length; or as irregularly shaped patches having diameters ranging from three to eight feet. In some instances several smaller veins ramify from the main seam, and after pursuing an irregular course of a few feet in a horizontal direction, they break off abruptly.

It is in and around the "Scutella" seam which forms the capping of the Lower Limestone, that the greatest number of veins and patches seem to occur; they are, however, found in the underlying divisions also.

The different varieties of rock vary greatly in their lithological aspects in different parts of the bed. In the upper divisions they are of a coarse texture and granitic appearance, and their fossil contents consisting of *Orbitoides*, *Echini*, and *spines* are plainly discernable; but in the lower parts, their close fine grain causes them to exhibit an exceedingly homogeneous appearance. Another locality in which the red variety is extensively developed is the bottom of the valley which is situated midway between Ras-el-Hecca and Uied tal Assiri on the northern coast of Gozo. The torrent that tears its way down the bed for a few occasional hours during the rainy season has there laid bare the basement rock, and has exposed a large patch of bright, red limestone that answers in every particular to the rock of which the numerous fragments that lie scattered over the surrounding slopes, are composed.

In common with the other rock fragments with which the country is strewn, there can be no doubt but that these black and red varieties were derived from the island's formations at a time when the forces of denudation were much more active than they are at present. The numerous oscillations of level that the islands bear evidences of having undergone, and the extensive erosion to which they were afterwards subjected by the combined action of frost and rain, are probably to be accounted among the most potent of the forces that assisted in planing down the islands' rocks, and in

distributing the debris throughout the Quaternary and the Recent deposits. The thin integument of soil that covers the surface even in those localities where denudation has been the most severe, masks from view the rocks beneath; and this, combined with the fact that but few clean cut sections of the Lower Coralline Limestone are exposed inland, affords an explanation for the obscurity of these thin veins of black limestone, and for the doubt with which their occurrence in the Malta rocks has hitherto been regarded.

VI.—The Discovery of *Terebratulina substriata*, Schlotheim, in Yorkshire.

By John Francis Walker, M.A., F.G.S., etc.

SEVERAL years ago Mr. W. H. Hudleston, Prof. J. F. Blake and myself obtained large quantities of *Waldheimia* (*Zeilleria*) *Hudlestoni*, Walker, from the quarry on the Suffield Heights near Scarborough. I had separated several specimens which appeared to differ from the typical form; on rearranging my collection, I carefully examined them, and found that they were covered with fine striæ and also had the characteristic form of the genus *Terebratulina*.

The bed in which they occur is described by Hudleston and Blake, Q.J.G.S. vol. xxxiii. p. 331. This quarry has been long noted for the quantity of small sponges, *Spongia floriceps*, *Spongia corallina*, etc., which it contains. It is to be noticed that Quenstedt "die Brachiopoden," p. 224, states that this brachiopod appears to prefer exclusively a spongy layer as its dwelling place. Quenstedt, *op. cit.* gives the following varieties of *Terebratulina substriata*, var. *alba*, from Weiss Jura, γ, and var. *silicea*, var. *marmorea* from Weiss Jura, δ.

The Yorkshire specimens appear to be most like the variety *Terebratulina substriata*, var. *alba*, but are generally less convex and have the striæ finer and more numerous. If this shell should require a varietal name it might be called var. *Suffieldensis*.

As Mr. S. S. Buckman and myself are preparing a paper on the species of Jurassic Brachiopoda which have been discovered since Davidson's work was completed, I will not further discuss this species. I have presented to the British Museum a specimen of this Brachiopod.

VII.—Recent Observations on the Geology of the Lizard District, Cornwall.

By Alexander Somervail, Esq.

DURING a stay of nearly six weeks, made last July and August, at the Lizard, Cornwall, I had ample opportunity of correcting former, and making some fresh observations.

With regard to the first of these, and to some of the strictures recently passed on them, I found that I had little or nothing to regret as to what I had already written on the subject, with the exception of the "felsitic-like-rock" at Housel Cove,[1] which I should now rather regard as a mass segregated, or separated out of the

[1] Geol. Mag. Vol. VI. 1889, p. 114.

common magma, than as an altered portion of the hornblende-schist as I then described it—my object at the time being to show that it was not a dyke; a view I am still convinced of. I now pass on to recent observations.

These latter observations were made over the whole area, that is, from Polurrian on the west to Porthallow on the east, both of these localities marking the boundary between the killas or slates on the north, and the igneous rocks of the Lizard district to the south.

I shall briefly localize these observations, beginning with:—

Porthallow.—In the killas or slates here, at a few feet from their junction with the hornblende and serpentine series, there is a quartzose-like-rock at the base of the cliff, immediately below the iron-lode described by Mr. J. H. Collins, F.G.S.[1] The relations of the quartzose-like-rock to the surrounding slates is exactly like that of an intruded igneous mass, which also in its upper portion contains included fragments of the slate. On breaking well into this intrusive like rock, its interior is found to present a very different aspect from its exterior; the former is chloritic-like, resembling a diabase that has undergone much alteration. It contains a large amount of iron-pyrites, and recalled to my mind the chloritic rocks of the Start area in Devonshire, especially those near, or at the junction with, the slates in the Bickerton Valley.

Following the cliff towards the Inn, at about 36 paces from which (near a building with outside stair and thatched roof) a gabbro (much decomposed) most unexpectedly occurs, where only the ordinary slates were hitherto supposed to exist. This gabbro has all the appearance of cutting through the slates and the arenaceous beds associated therewith; but on this point I could not arrive at absolute certainty. In the cliff behind the Inn there is also diorite of the greenstone type, but much decomposed. Higher up the road, behind and forming the foundations of the cottages, there is more gabbro and diorite, the former rock cropping out on the roadway and continuing southwards in the direction of the road.

The occurrence of these rocks, where only slates were supposed to exist, is of considerable importance, especially as they seem to rise through the slates, as does also the adjoining serpentine at Pengarrock, which, if the case, when connected with the gabbro and serpentine, and perhaps even the greenstone occurring at Nare Head, Gerran Bay, would clearly prove these Lizard eruptive rocks to be subsequent to the killas. However this may be, the occurrence of the gabbro and diorite or greenstone, forming the cliff described, will necessitate a very considerable alteration of the boundary on the present map.

Returning again to the junction on the coast between the eruptives and slates, I examined the hornblende-schist which immediately succeeds the serpentine, tracing it along the entire length of the top of the cliff where it has been quarried. It certainly is a very variable rock, in some portions schistose, in others quite massive; in one portion a diorite, in another passing into a variety of green-

[1] Quart. Journ. Geol. Soc. vol. 40, 1884, p. 463.

stone, and other portions with a well-defined porphyritic structure resembling the variety at Porthoustock. In a sentence, there is every grade between a diorite and a greenstone, schistose and massive, non-porphyritic and porphyritic.

Porthoustock.—Here I examined the greenstone on the extreme south side of the Cove, and found it, as I had done on previous occasions, traceable through many varieties into fine-grained varieties resembling an aphanite, and others into epidiorite, which latter had an apparent passage into the hornblende-schists proper.

Passing over the great alternating succession of gabbro, and greenstone or epidiorite (which I have already described),[1] with the gradual decrease of the latter towards Coverack, there is nothing I have specially to note except a very remarkable and beautiful variety of gabbro occurring as a dyke in the serpentine on the immediate west side of Coverack Pier. The diallage in this gabbro has a brilliant metallic silvery lustre, being quite like a mica at first sight; the only gabbro of the kind that I am acquainted with.

Black Head area.—At a little distance N.W. of Chynhal Point, near the base of the cliff, a diorite dyke one foot in thickness cuts through the serpentine; and at the Black Head, also at the base of cliff, there are two dykes of a similar character in the serpentine which have a N.N.W. and S.S.E. strike or trend.

In this area the serpentine shows evidence of much disturbance, and from this cause, or as a result of cooling, is full of structures; among which is a strongly-marked surface foliation which has the usual N.N.W. and S.S.E. strike which is common to this structure in the serpentine of nearly every locality.

On the west side of Beagle Hole there are two more diorite dykes in the serpentine, and near the Point there is one of gabbro; and two or three more of the latter occur (beside those of Downance and Lankidden Coves already known and recorded) on the west side of Lawn Vinoc. Beside these I have no doubt that careful search would discover many more in what are at present regarded as unbroken masses of serpentine. Passing over a large area I have nothing special to record until near—

Polpeor Cove.—It is here and to the westward that the great development of mica-schist occurs, the origin of which is a problem yet waiting solution. Many appearances would seem to indicate that it is an advanced stage in the metamorphism of the hornblende-schist, for the reasons already given in my former papers.[2] I have only now to add that on extracting a number of lenticular or nodular decomposed masses from the heart of the mica-schist on the west side of the road leading down into the Cove, and on breaking them up their centres were found to consist of the green porphyritic diorite or diabase-like rock so common in the reefs of the Cove. To this may be added the fact that the mica-schist west of Polpeor Cove, at and near the Lizard Point, contains similar nodules of the ordinary hornblende-schist.

[1] Geol. Mag. Vol. VI. 1889, p. 425.
[2] Geol. Mag. 1890, Vol. VII. p. 163.

Mullion Cove.—To the south-west of the Cove near to Ladan Ceyn, in the serpentine there is a dyke[1] or vein of nearly pure felspar containing some white mica, biotite, etc., with a nearly north and south strike.

Henscath to Polurrian Cove.—The Headland of Henscath is by no means the most northerly termination of the serpentine, as I found it continued in the cliff a little below the level of its top quite continuously among the hornblende-schists as far north as Carrag-luz, and also on each side of the upper portion of the Cove there. There is also an impure or transitional variety on the south-west side of Rocky Pedn-y-ke which now brings the serpentine within a few hundred yards of Polurrian Cove where the junction occurs between the hornblende and the killas.

REVIEWS.

I.—The System of Mineralogy of James Dwight Dana, 1837–1868. Descriptive Mineralogy (Sixth Edition). By Edward Salisbury Dana, Professor of Physics and Curator of the Mineral Collection, Yale University. Entirely Re-written and much Enlarged. Illustrated with over 1400 figures. (London: Kegan Paul, Trench, Trübner & Co., Limited, 1892. Royal 8vo. pp. lxiv. and 1134.)

In the Geological Magazine, for October, 1868 (Vol. V. pp. 460–463), we had the pleasure to notice the fifth edition of this most valuable work, which has been before the scientific world since 1837, and is likely to continue, for many years to come, the standard treatise on Mineralogy.

In the fifth edition the veteran mineralogist, Prof. J. D. Dana, was assisted in his difficult task by Prof. Geo. J. Brush, and the work was then re-written and enlarged to 827 pages.

The present (sixth) edition, issued after an interval of nearly twenty-four years, has been entirely re-written and much enlarged by Professor E. S. Dana, son of Professor J. D. Dana, and already favourably known to mineralogists as the author of a "Text-book of Mineralogy," published in 1877 (Trübner & Co.), and noticed in the Geological Magazine (Decade II. Vol. IV. 1877, pp. 328–29).

During the past quarter of a century the science of Mineralogy has made very rapid progress, indeed there has probably never been a time of more active mineralogical investigation. A striking indication of this activity is shown by the many new periodicals, recently started, devoted largely, if not exclusively, to Mineralogy. The activity of mineralogical workers is still further evidenced by the fact that within the past twenty-four years nearly one thousand new names have been introduced into the science—unfortunately, not all "new species," although this has been claimed for most of them.

Nor has the important subject of the optical properties of minerals been neglected, new and improved methods and instruments for

[1] As the locality of this dyke or vein is rather difficult to find, the Serpentine worker in the Cove can guide anyone to it.

optical and microscopical study having been developed and brought within the reach of all mineralogical observers. New means of observation have not only increased our knowledge of the optical constants of many species, but have developed new views in regard to the molecular structure of crystals. In Chemical Mineralogy, also, there has been rapid progress; on the theoretical side, in the way of explaining the composition of complex species and groups of species; again on the analytical side, and perhaps even more by the development of the synthetic processes. The last-mentioned methods, in the hands of skilful chemists, have resulted in the reproduction in the laboratory of most of the prominent mineral species, as the felspars, quartz, the pyroxenes and chrysolites, amphibole, corundum, etc.; thus throwing much light upon the composition of species and their formation in nature.

Great care has been bestowed by the author upon the crystallographic portion of the subject; and the attempt has been made to trace back to the original observer the fundamental angles for each species—then the axes have been recalculated from them, and finally the important angles for all common forms have been calculated from these axes. Where there has been no other independent means of verification at hand, the angles have, in most cases, been calculated a second time independently. In this way the author hopes that a fair degree of accuracy has been attained. The Millerian indices have been adopted throughout.

The habits of the crystals, methods of twinning, and the physical characters, especially those on the optical side, have been carefully re-written and in general are given with much fullness. In the list of analyses, all are given that are likely to prove useful for a complete understanding of the composition of each species. This means all reliable analyses in the case of the rare species or those of complex composition.

In the Introduction, after explaining the order observed in the description of the species and the abbreviations used, the author devotes 20 pages to Crystallography, giving as briefly as possible an explanation of the six systems of crystallization. Each system is carefully illustrated, and tables of the more important angles are given. The next subdivision treats of Physical Mineralogy—(1) Characters depending upon cohesion; as Cleavage, Fracture, Tenacity, Hardness. Then (2) Specific Gravity or Density. (3) Characters depending upon light—as Lustre, Colour, Diaphaneity, or degree of transparency; special optical properties and anomalies. Uniaxial and Biaxial Crystals are then explained. (4) Characters relating to Heat; and (5) to Magnetism and Electricity. These latter characters are so far special, that they are treated very briefly in this work, under the individual species; references, however, are given to the most important papers on the subject.

The next section is Chemical Mineralogy: the classification adopted in this work follows, first, the chemical composition, and secondly the crystallographic and other physical characters, which indicate more or less clearly the relations of individual species.

The general classification is as follows:—

I. Native Elements.
II. Sulphides, Selenides, Tellurides, Arsenides, Antimonides.
III. Sulpho-salts.—Sulpharsenites, Sulphantimonites and Sulphobismuthites.
IV. Haloids.—Chlorides, Bromides, Iodides; Fluorides.
V. Oxides.
VI. Oxygen-salts.
    1. Carbonates.
    2. Silicates, Titanates.
    3. Niobates, Tantalates.
    4. Phosphates, Arsenates, Vanadates; Antimonates; Nitrates.
    5. Borates, Uranates.
    6. Sulphates, Chromates, Tellurates.
    7. Tungstates, Molybdates.
VII. Salts of Organic Acids: Oxalates, Mellates, etc.
VIII. Hydrocarbon compounds.

The author has shown much good sense in modifying the objectionable terminations proposed in the fifth edition: such as "Oxyds," "Sulphids," "Selenids," "Arsenids"; but others have been retained: thus "Iodite" is still written "Iodyrite"; "Haüynite" is preferred to "Haüyne"; "Nosean" is written "Noselite"; "Sphalerite" is preferred to "Blende," although the latter is much better known. Common salt still figures as "Halite."

These, however, are trivial matters when one considers the enormous labour entailed in the careful production of such a monumental work.

Under the head of "Nomenclature" (pp. xl.-xlv.) some excellent rules are laid down, but several of these are more honoured, by mineralogical Godfathers, in the breach than in the observance as *e.g.* "the addition of the termination *ite* to proper names in modern languages (names of places, persons, etc.), but the making this or any other syllable a suffix to *common* words in such languages *is barbarous.*" The number of such names is, however, far too numerous ever to hope for their elimination.

There is an excellent and concise Bibliography which will be found very convenient to the student.

The Catalogue of American Localities of Minerals (51 pp.) will also be of very great service, forming a useful Gazetteer to many little known and obscure names of places.

The index is excellent and contains over 6000 references.

We cannot speak in too high terms of the way in which this new edition of Dana's Mineralogy is produced. The editing has been carefully performed, and the illustrations and typography are admirable. The task must have been one of *extreme difficulty* owing to the great number of tables of figures of measurements of angles, chemical analyses, and abbreviations; and the varieties of types used throughout the text.

We congratulate the author on the issue of so excellent a piece of work, which must command a world-wide circulation and be in request wherever Mineralogy is taught.

II.—Notice Geologique sur le Bas Boulonnais. Par E. Rigaux. Extrait du XIV^e. vol. des Mémoires de la Société Académique de Boulogne. 1892.

THIS is the second edition of a work published by the Boulogne Society in 1865; it is now revised and augmented—many additions being due to the labours of Gosselet, Pellat, Douvillé, de Loriol, and Cossmann. It is, perhaps, unusual for an Academic Society to issue a revised edition of a Memoir, but the proceeding in the case before us is one to be commended, as the information regarding a particular area is summarized and brought up to date.

The strata exposed in the area include the Devonian, Carboniferous, Jurassic, and Cretaceous; Silurian rocks have also been proved in several places beneath the Secondary strata.

The author gives an account of the principal stratigraphical divisions of each formation, notes the fossils found at different horizons, and gives some general lists of species. He has not followed the fashion of subdividing all the strata into zones, and in many respects his plan is more satisfactory, as the facts are thus clearly stated, and general comparisons can be made with the fossiliferous horizons in other places by those desirous of doing so.

The Devonian rocks commence with the Givetian stage, which includes slates, conglomerates, and grits, overlaid by limestone (Calcaire de Blacourt) with *Stringocephalus Burtini*, etc. Then comes the Frasnian stage, divided into the (1) Beaulian and (2) Ferquian sub-stages; they include a series of slates and limestones with *Spirifer orbelianus*, *Chonetes Douvillei*, *Pentamerus brevirostris*, *Streptorhynchus Bouchardi*, *S. elegans*, and *Rhynchonella pugnus*, in the lower division; and *Athyris concentrica*, *Strophomena latissima*, and *Chonetes armata* in the upper division. Common to these two divisions are *Spirifer Verneuili*, *Atrypa reticularis*, etc. The highest stage, the Famennian, includes grits and slates with *Bellerophon bilobatus*, *Cucullæa trapezium*, etc.

Carboniferous rocks rest conformably on the Devonian, and include two divisions, (1) Limestone, and (2) Coal-measures. The Carboniferous Limestone comprises lower beds with *Productus Cora*, middle beds with *Productus undatus*, *Spirifer glaber*, *Rhynchonella pleurodon*, *Terebratula hastata*, etc., and upper beds with *Productus giganteus*, *P. semireticulatus*, *Athyris Roissyi*, etc. The Coal-measures are shown at the surface in but few localities; the beds have been much disturbed, and, as proved by borings, older rocks have in places been thrust over them.

Resting directly on the Palæozoic rocks in this area, as under London, there are found strata of Great Oolite age. Beds grouped as Bathonian, and representing the upper part of the Great Oolite (Forest Marble, etc.) and Cornbrash are described, and a long list of fossils is given.

The Brachiopoda are curiously placed, both in this list and in that of the Oxfordian fossils, between the Fishes and the Cephalopods. We rejoice that the author indexes his Ammonites under this generic

name: with the Brachiopods we have to translate the names such as *Zeilleria*, *Dictyothyris* and *Eudesia* into the more familiar and customary *Waldheimia* and *Terebratula*. Some of the Gasteropods, such as *Hydatina*, *Diempterus*, *Diartema*, *Chenopus*, *Eustoma*, *Rigauxia*, *Eligmoloxus*, etc., would be wholly unintelligible to most geologists were it not for their places in the lists. Some, at any rate, of these names might have been put in brackets with the more general generic names in front. It is impossible for a student to keep pace with the minor changes of nomenclature, most of which should be *additions* rather than *alterations*; for important as these are to the specialist, they are only a source of ambiguity to others. We do not find fault with M. Rigaux in particular; but we hope that he and others will see, if not the error, at any rate the inconvenience of their ways. For surely the object of scientific work should be to lighten labour, and not unnecessarily to increase it.

It is interesting to note that *Terebratula globata* is recorded from both Great Oolite and Cornbrash, while *Terebratula* (*Dictyothyris*) *coarctata* is given as rare in the latter formation.

The general succession of Oxfordian beds compares well with the strata in this country. There are beds with *Ammonites modiolaris*, and higher stages with *A. Duncani*, *A. Mariæ*, *A. Lamberti*, etc. No doubt, as the author admits, he has included with his Oxfordian division beds that in this country would be classed as Corallian; of these the limestone of Houllefort contains several Corals, *Cidaris florigemma* and other Echinoderms, *Chemnitzia* (*Pseudomelania*) *heddingtonensis*, and other species characteristic of our Corallian rocks. Higher beds are grouped by M. Rigaux as Corallian and Astartian, both of which divisions would also (he admits) be included in our Corallian; although the upper beds show, as in this country, the incoming of Kimeridgian species.

In the Kimeridgian stage are included representatives of Kimeridge Clay and Portland Beds, the latter being, as the author suggests, the littoral facies of the division. In the table at the end of the work the "Portlandian" Beds are, however, grouped separately, but the strata so-called mainly correspond with our Upper Portland Beds.

The fact that each country must have its own minor divisions is shown by the varying characters of the strata and the varying distribution of the fossils.

Thus the 'Gres de la Creche' (which comes beneath marls with *Discina latissima*) yields *Neritoma sinuosa*, *Trigonia Pellati*, *Mytilus autissiodorensis*, *Pterocera Oceani*, *Hemicidaris purbeckensis*, etc. The overlying 'Marnes à *Discina latissima* et *Cardium morinicum* yield *Ammonites biplex*, *Belemnites Souichii*, *Exogyra* (*Ostrea*) *bruntrutana*, *Thracia depressa*, etc. We should be inclined to group these beds with our Lower Portlandian; but M. Rigaux groups only the succeeding 'Marne à *Ostrea expansa*' with the "Portland Sands." The same division is elsewhere marked as 'Marne à *Perna Bouchardi*,' and it contains some of the forms previously mentioned, also *Astarte Sæmanni*, *Cyprina implicata*, *Pecten lamellosus*, *Discina latissima*, and *Lingula ovalis*. The highest Portlandian beds comprise the 'Calcaire

à *Trigonia gibbosa*': this contains *Ammonites boloniensis* and other characteristic fossils, also *Cyrena Pellati*, and *Cidaris florigemma*? (? derived). Conglomeratic and remanié beds occur at several horizons from the base of the 'Marne à *Perna Bouchardi*' and upwards, so that locally some of the Upper Portlandian horizons are absent: and such beds would account for the preservation of *Cidaris florigemma*.

The highest Portland Beds are covered in places by sands and sandy limestones with *Cypris*, and by concretionary limestone with *Astarte socialis* and *Candona bononiensis*. These belong to the Purbeck Beds, which are grouped with the Wealden Beds, as Wealden-Purbeck. Sometimes the Purbeck Beds rest on lower '*assises*' of the Portland Beds.

The Wealden Beds which comprise sands and greenish sandy clay are conglomeratic and rest in places directly on Portland Beds.

The Cretaceous Beds (grouped under the unfortunate term 'Infracrétacé') include (1) Ferruginous sands and gravel, and white clays, with *Ostrea Leymerii* and *Terebratula* (*Zeilleria*) *pseudojurensis*; and (2) grey or green sands with *Ammonites mamillaris*, and also ferruginous and phosphatic nodules.

These two divisions are grouped as Aptian, while the overlying clays with *Ammonites splendens*, *A. lautus*, *A. inflatus*, etc., are grouped as Albian or Gault.

The unconformities previously noted are minor and local compared with the great discordance between these Cretaceous beds and the underlying strata; for they rest indifferently on the several Jurassic stages, on the Carboniferous, and on the Devonian rocks.

The following species are described and figured:—*Athyris Betencourti*, Givetian; *Spirifer Barroisi*, *Rhynchonella Le Meslii*, *Chonetes Douvillei*, *Limanomya Grayiana*, Bouchard, *L. multicostata*, Bouch. MS., and *L. lineolata*, Bouch., Frasnian; *Cyrtina Lonquetii*, Carboniferous; *Trigonia Seeleyi*, Bathonian; *Rhynchonella Pellati*, *Opis Pellati*, *Delphinula Parkeri*, and *Oncospira Legayi*, Oxfordian.

H. B. W.

III.—The Development of the Shell in the coiled stage of *Baculites compressus*, Say.

LAST year Mr. Amos P. Brown announced[1] the discovery of the young of *Baculites compressus*, Say, in some Cretaceous marl from near Deadwood, South Dakota, and showed that the genus *Baculites* was coiled in its earlier stages, the coiled stage of *B. compressus* consisting of two to two and one-half whorls and having a diameter of 0·8 to 1 mm. By breaking the shell back from the straight portion to the protoconch, Mr. Brown has now been able to trace out the development of the coiled portion of the shell.[2]

The protoconch is ellipsoidal, wider than high; it is wider than each of the succeeding whorls, and therefore when the coiled portion

[1] Proc. Acad. Nat. Sci., Philadelphia, 1891, pp. 159-160, woodcut. Noticed in this Magazine, New Series, Dec. III. Vol. VIII. 1891, p. 316.

[2] See Proc. Acad. Nat. Sci., Philadelphia, 1892, pp. 136-141, pl. ix.

of the shell is viewed edgewise the rounded ends of the protoconch may be seen slightly projecting on either side.

The suture line of the first septum is marked by a prominent narrow saddle over the siphuncle, as in the Angustisellati of Branco. According to Mr. Brown's observations, "the total number of main lobes and saddles of the adult shell is apparently developed at the second septum."

The shape of the septa gradually changes from the lunate form of the first septum "into a more and more circular form, until it becomes completely circular in the straight portion of the shell," and in the straight portion, which "begins somewhere between the twentieth and twenty-fifth septa," the form of cross section "passes gradually from a circular to an ovoidal, laterally-compressed form, and finally in the adult into a somewhat triangular form."

"The outer nacreous shell when preserved is found to be marked by minute tuberculations of irregular shape; these in turn give place to the parallel curved lines seen in the adult shell. These parallel lines first appear about the fourteenth septum, and they soon completely obscure the tuberculation. Between the first and second sutures there is apparently an interruption in the growth of the shell, appearing as a line resembling a suture line. This line seems to be slightly raised above the general shell substance; it extends over the end of the ventral lobe of the second suture and back in a simple curve to near the lateral ends of the first suture. In breaking away the nacreous shell substance to follow the sutures, the break nearly always follows this line, leaving the protoconch covered by the original shell. Over the area thus left of the original shell substance the tuberculations are found to be more circular in outline and closer together than in the succeeding portions of the shell. It is believed that the portion of the shell thus bounded represents the original embryonic chamber, or protoconch, which would thus extend beyond the point where the first septum was subsequently developed. A section in the plane of the spiral, but not quite median, showed the shell to be composed of successively deposited layers, and the first of these was seen to extend a short distance beyond the first septum, thus tending to confirm the above belief." An examination of the young of *Scaphites Conradi*, Morton, showed that in this shell also the outer limit of the protoconch was between the first and second septa.

Mr. Brown states that after considerable investigation he is not able as yet to trace the phylogeny of the species. G. C. C.

IV.—The Orthoceratidæ of the Trenton Limestone of the Winnipeg Basin. By J. F. Whiteaves. Transactions of the Royal Society of Canada, Vol. IX. 1891, pp. 77–90, Pls. V.–XI.

THE species here described were, with one exception (from the Nelson River, in Keewatin), obtained in the province of Manitoba, "either from the valley of the Red River (at Lower Fort Garry or East Selkirk), the western shore of Lake Winnipeg, or from some of the numerous islands in that lake." "The term

'Trenton Limestone' is used in a somewhat comprehensive sense, to include all those highly fossiliferous deposits which immediately and conformably overlie the St. Peter's sandstone, and underlie the Hudson River formation." All the specimens are now in the Museum of the Geological Survey of Canada at Ottawa.

The species described are as follows: *Endoceras annulatum*, Hall, var., *E. subannulatum*, Whitfield, *E. crassisiphonatum*, sp. nov., *Orthoceras Simpsoni*, Billings, *O. semiplanatum*, sp. nov., *O. Selkirkense*, sp. nov., *O. Winnepegense*, sp. nov., *Actinoceras Richardsoni*, Stokes, *A. Bigsbyi*, Bronn, *A. Allumetense*, Billings, sp., *Sactoceras Canadense*, sp. nov., *Gonioceras Lambii*, sp. nov., *Poterioceras nobile*, Whiteaves, *P. apertum*, Whiteaves, *P. gracile*, sp. nov. The species are here given in the order in which the author describes them, which is that adopted by von Zittel in the second volume of his "Handbuch der Palæontologie" (1887); but the genera *Actinoceras* and *Sactoceras* are "regarded as distinct from *Orthoceras*, and *Poterioceras* from *Gomphoceras*."

The most interesting species described in this brief monograph, both for its rarity and peculiar form, is the *Gonioceras*. This is represented by a single, large example, rather more than ten inches long, and having a maximum diameter at the larger end of six inches and a half, and at the smaller end of five inches. It differs from the type of the genus (*G. anceps*, Hall) chiefly in its much greater size, and in the smaller size and peculiar shape of its siphuncle; the septa are also less curved laterally than they are in *G. anceps*. In the latter feature *G. Lambii* is scarcely typical of the genus to which it is assigned; but the compressed lenticular form of the shell, and the position of the siphuncle, justify the author in referring it to *Gonioceras*.

All the species are figured with one exception (*Pterioceras nobile*). Though only outlines, the figures are executed with so much boldness and artistic spirit that the absence of shading can hardly be considered as a serious drawback. A. H. F.

REPORTS AND PROCEEDINGS.

I.—The Royal Society of Canada, Eleventh Annual Meeting, May 30 to June 2, 1892.

FIFTEEN papers were read by Fellows of the Royal Society of Canada at its last meeting, just closed, in Section (IV.) of Geology and Biology, and five more in the Department of Chemistry and Physical Sciences (Section III.).

Of the latter, Professor Chapman's paper "On a New Form of Application Goniometer" is of interest to geologists and mineralogists, as is also his additional note "On the Mexican Type in the Crystallization of the Topaz, with some Remarks on Crystallographic Notation."

Then comes Professor J. G. MacGregor's address on "The Fundamental Principles of Abstract Dynamics." Here the inde-

pendence of Newton's three Laws of Motion is first considered, and an attempt is made to establish it; Maxwell's deduction of the first from the "doctrine of space and time," and Newton's supposed deduction of the third from the first being subjected to criticism.

Geology and Palæontology come in for seven papers, as follows: Presidential Address, by Mr. G. F. Matthew, of St. John, N.B., "On the Diffusion and Sequence of the Cambrian Faunas." In this address an attempt is made to distinguish the littoral and warm-water faunas of the Cambrian age from those which mark greater depths of the sea and cooler water. On the hypothesis that species capable of propagating their kind in the open sea would spread rapidly to all latitudes where the temperature of the sea was favourable, such forms as the Graptolites are taken as fixed points in the successive faunas. The relation to the Graptolites is noted of various species of other groups of animals, as they occur in different countries. It thus seems that several genera appeared first in America, and afterwards spread to Europe. On the other hand, a very close connection no doubt existed between the Cambrian faunas of the north of Europe and those of the Atlantic coast of North America. Hence it is inferred that the temperature of the sea of these two coasts was similar, and the connection between them direct and unimpeded. Equal temperatures in these different latitudes would be maintained by a cold current flowing from the North European to the North Atlantic Coast. The evidence available seems to point to a migration of the American species by a route to the west and north of the main part of the Atlantic Basin.

Mr. Matthew contributed an additional paper, entitled "Illustrations of the Fauna of the St. John Group, No. VII." This is the final paper on this subject, and treats chiefly of the fauna of the highest horizon in the group. It will be accompanied by a list of all the species of the St. John group, showing the several horizons at which they have been found. From the highest horizon itself, the species are of the age of those of the Levis shale, or thereabout, as shown by the Graptolites found here. There are several Orthids, some of which are identical with, or are varieties of, species of the Levis limestone described by Billings. The few Trilobites known are of Cambrian types, and include a *Cyclognathus* allied to *C. micropygus* and a *Euloma*. Several minute Pteropods occur in these shales, with the Graptolites.

Sir William Dawson, F.R.S., presented a paper "On the Correlation of Early Cretaceous Floras in Canada and the United States and on Some New Plants of this Period." The purpose of this paper is to illustrate the present state of our knowledge respecting the flora of Canada in the early Cretaceous, and to notice some new plants from Anthracite, N. W. Territory, collected by Dr. H. M. Ami, and from Canmore, collected by Dr. Hayden. It is a continuation of the author's paper on the "Mesozoic Floras of the Rocky Mountain Region of Canada," in the Transactions of the Royal Society of Canada for 1885.

Sir William then introduced Dr. Ami's paper "On the Occurrence

of Graptolites and other Fossils of Quebec-Age in the Black Slates of Little Metis, Que." The paper contains notes on, and descriptions of, Graptolites and other fossils from a small but interesting collection made by Sir William Dawson in rocks closely related to those from which the remarkable fossils were described conjointly with Dr. George Jennings Hinde.

Mr. J. F. Whiteaves, palæontologist and zoologist to the Dominion Geological Survey, read two papers, and introduced a third by Mr. Lawrence Lambe. In his first paper on the "Fossils of the Hudson River Formation in Manitoba," Mr. Whiteaves gives an historical sketch of the discovery and collection of fossils of that age, by Dr. R. Bell, in 1873; by Dr. Ells, in 1875; Dr. Bell, later, in 1879; and by Messrs. T. C. Weston and D. B. Dowling, in 1884 and 1891–92, respectively. The object of the present paper is to give as complete a list as possible of the fossils of this formation in Manitoba. There are now as many as sixty species in the museum of the Survey at Ottawa. Mr. Whiteaves's second paper deals with "Notes on the Land and Fresh-water Mollusca of the Dominion." Mr. Lambe's paper contains an account of the results obtained by that gentleman from a microscopical examination of recent sponges collected in the waters of the Pacific, along the British Columbia or Canadian coast. The paper is entitled, "On Some Sponges from the Pacific Coast of Canada and Behring Sea." It will be illustrated with drawings made by the author, who is artist to the Geological Survey Department.

Professor L. W. Bailey, Ph.D., of Frederickton, New Brunswick, gives the result of his "Observations on the Geology of South-Western Nova Scotia," in the counties of Shelburne and Yarmouth. A careful description of the various contacts and occurrences of the auriferous rocks and other masses follows a review of the geological structure of the district in question. A geological map accompanies the paper.

"On Palæozoic Corals" is the title of Professor Chapman's contribution to palæontological science. It is an attempt to simplify the determinations of genera in the so-called "Tabulated and Rugose Corals of Palæozoic Rocks."

Dr. Wesley Mills's paper on "Hibernation and Allied States in Animals."

Dr. George Lawson presented two important contributions to botanical research. The one bore "On the Literary History and Nomenclature of the Canadian Ferns," the other consisted of "Notes Supplementary to the Revision of Canadian Ranunculaceæ."

Rev. Moses Harvey, of St. John's, Newfoundland, and a new Fellow of the Society, contributed a most important paper "On the Artificial Propagation of Marine Food-Fishes and Edible Crustaceans."

Mr. James Fletcher, F.L.S., and Dominion entomologist, contributed two papers in that branch of work. The first was entitled, "Report on a Collection of Coleoptera made on the Queen Charlotte Islands by Rev. J. H. Keen and J. Fletcher"; the second, "The use of Arsenites as Insecticides." H. M. A.

II.—Geological Society of London.

June 22nd, 1892.—W. H. Hudleston, Esq., M.A., F.R.S., President, in the Chair.—The following communications were read:

1. "Contributions to a knowledge of the Saurischia of Europe and Africa." By Prof. H. G. Seeley, F.R.S., F.G.S.

The Saurischia are defined as terrestrial unguiculate Ornithomorpha, with pubic bones directed downward, inward, and forward to meet in a ventral union. The forms of the pelvic bones vary with the length of the limbs, the acetabulum becoming perforate, the ilium more extended, the pubis and ischium more slender, and the sacrum narrower as the limb bones elongate. The order is regarded as including the Cetiosauria, Megalosauria, and Aristosuchia or Compsognatha.

The Cetiosaurian pelvis has been figured in the Quart. Journ. Geol. Soc.; and a restoration is now given of the pelvis in *Megalosaurus*, *Streptospondylus*, and *Compsognathus*.

The characters of the skull are evidenced by description of the hinder part of the skull in *Megalosaurus* found at Kirtlington, and preserved in the Oxford University Museum. In form and proportions it closely resembles *Ceratosaurus*, and the corresponding region of the head in Jurassic Ornithosauria. The brain-cavity and cranial nerves are described, and contrasted with those of *Ceratosaurus*.

The skull in Cetiosauria, known from the American type *Diplodocus*, is identified in the European genus *Belodon*, which is regarded as a primitive Cetiosaurian.

Part 2 discusses the pelvis of *Belodon*, restored from specimens in the British Museum, and regarded as Cetiosaurian. A restoration of the shoulder-girdle is made, and found to resemble that in Ichthyosaurs, Anomodonts, and Dinosauria. The vertebræ in form and articulation of the ribs are Saurischian, the capitular and tubercular facets being vertical in the dorsal region, and not horizontal as in Crocodiles. The humerus shows some characters in common with that of *Stereorachis dominans* in the epicondylar groove. In general character the limb-bones are more Crocodilian than the axial skeleton. The interclavicle is described, and regarded as a family characteristic of the Belodontidæ.

In the 3rd part an account is given of *Staganolepis*, which is regarded as showing a similar relation with the Megalosauria, to that of *Belodon* with the Cetiosauria. This interpretation is based chiefly upon the identification of the pubic bone in *Staganolepis*, which has the proximal end notched as in *Zanclodon* and *Streptospondylus*; and the inner ridge at the proximal end is developed into an internal plate. A note follows on the pelvis of *Aëtosaurus* which is also referred to the Saurischia on evidence of its pelvic characters, approximating to the Cetiosaurian sub-order.

Part 4 treates of *Zanclodon* which is regarded as closely allied to *Massospondylus*, *Euskelesaurus*, and *Streptospondylus*. It is founded chiefly on specimens in the Royal Museum at Stuttgart, and in the University Museum at Tübingen. The latter are regarded as possibly referable to *Teratosaurus*, but are mentioned as *Zanclodon*

Quenstedti. The pelvis is described and restored. *Zanclodon* has the cervical vertebræ relatively long, as compared with *Megalosaurus*, and small as compared with the dorsal vertebræ, which have the same Teleosauroid mode of union with the neural arch as is seen in *Streptospondylus* and *Massospondylus*. The sternum, of Pleininger, is the right and left pubic bones; but there is much the same difference in the proximal articular ends of those bones in the fossils at Stuttgart and Tübingen, as distinguishes corresponding parts of the pubes in *Megalosaurus* and *Streptospondylus*. The ilium is more like that of *Palæosaurus* and *Dimodosaurus*. The limb-bones and digits are most like those of *Dimodosaurus*, but the teeth resemble *Palæosaurus*, *Euskelesaurus*, *Megalosaurus*, and *Streptospondylus*.

Part 5 discusses *Thecodontosaurus* and *Palæosaurus* upon evidence from the Dolomitic Conglomerate in the Bristol Museum. An attempt is made to separate the remains into those referable to *Thecodontosaurus* and those belonging to *Palæosaurus*. The latter is represented by dorsal and caudal vertebræ, a scapular arch, humerus, ulna (?), metacarpals, ilium, femur, tibia, fibula, metatarsals, and phalanges. These portions of the skeleton are described. There is throughout a strong resemblance to *Zanclodon* and other Triassic types. A new type of ilium, and the humerus originally figured are referred to *Thecodontosaurus*.

Part 6 gives an account of the South African genus *Massospondylus*. It is based partly upon the collection from Beaucherf, in the Museum of the Royal College of Surgeons, referred to *M. carinatus*; and partly upon a collection from the Telle River, obtained by Mr. Alfred Brown, of Aliwal North, referred to *M. Browni*. The former is represented by cervical, dorsal, sacral, and caudal vertebræ; ilium, ischium, and pubis; femur, tibia; humerus, metatarsals, and phalanges. The latter is known from cervical, dorsal, and caudal vertebræ, femur, metatarsals, and bones of the digits. The affinities with *Zanclodon* are, in some parts of the skeleton, stronger than with *Euskelesaurus*.

Part 7 gives an account of *Euskelesaurus Browni*, partly based upon materials obtained by Mr. Alfred Brown from Barnards Spruit, Aliwal North, and partly on specimens collected by the author, with Dr. W. G. Atherstone, Mr. T. Bain, and Mr. Alfred Brown, at the Kraai River. The former series comprises the maxillary bone and teeth, vertebræ, pubis, femur, tibia and fibula, phalanges, chevron bone and rib. The latter includes a cervical vertebra and rib, and the lower jaw. The teeth are stronger than those of *Teratosaurus*, or any known Megalosaurian. The anterior part of the head was compressed from side to side, and the head in size and form like *Megalosaurus*, so far as preserved. The pubis is twisted as in *Staganolepis* and *Massospondylus*, with a notch instead of a foramen at the proximal end, as in those genera; and it expands distally after the pattern of *Zanclodon*. The chevron bones are exceptionally long, and the tail appears to have been greatly elongated. The femur is intermediate between *Megalosaurus* and *Palæosaurus*, but most resembles *Zanclodon* and *Massospondylus*. The tibia in its

proximal end resembles many Triassic genera; and in its distal end is well distinguished from *Massospondylus* by its mode of union with the astragalus. The claw-phalanges are convexly rounded, being wider than is usual in Megalosauroids. The lower jaw from the Kraai River gives the characters of the articular bone, and the articulation, as well as of the dentary region and teeth. The cervical vertebra is imperfect, but is remarkable for the shortness of the centrum, being shorter than in *Megalosaurus*.

In Part 8 an account is given of *Hortalotarsus skirtopodus* from Barkly East, preserved in the Albany Museum. It is an Euskelesaurian, and exhibits the tibia and fibula, and tarsus. There is a separate ossification for the intermedium, which does not form an ascending process; and the astragalus is distinct from the calcaneum. The metatarsals are elongated, and the phalanges somewhat similar to those of *Dimodosaurus*.

Part 9, in conclusion, briefly examines the relations of the Saurischian types with each other, and indicates ways in which they approximate towards the Ornithosauria. It is urged that the Ornithosauria are as closely related to the Saurischia as are the Aves to the Ornithischia; and that both divisions of the Saurischia approximate in *Staganolepis* and *Belodon*. Finally, a tabular statement is given of the distribution in space and time of the 25 Old-World genera which are regarded as probably well established. Eight of these are referred to the Cetiosauria, thirteen to the Megalosauria, and four to the Aristosuchia or Compsognatha.

2. "Mesosauria from South Africa." By Professor H. G. Seeley, F.R.S., F.G.S.

The author gives an account of specimens of *Mesosaurus pleurogaster* (Seeley) obtained from the shales at the Kimberley diamond-mine. They are of small size, and show generic identity with the Paris type, but indicate an animal with a long tail, with the hind limbs well developed. The centra of the vertebræ are barrel-shaped, contracting to the articular faces, which are conically cupped. The dorsal ribs have the usual subcylindrical character and development; but the abdominal armour is more like that of a Plesiosaur, only the sternal ribs are thin and flat. The vertebræ appear to give attachment to the dorsal ribs in an unusual way, which suggests the condition in the Theriodontia, but without distinct tubercles or facets; so that the slender head of the rib lies in the depression between two centrums. In the early caudal vertebræ the transverse processes are stronger, the neural spines long and compressed, and chevron bones well developed. Details are given of the structure of the tarsus and hind limb.

A new example of *Mesosaurus tenuidens* from Albania, preserved in the South African Museum, shows many details of structure more perfectly than in the type-specimen; and the author describes the skull, cervical and dorsal vertebræ, shoulder-girdle, ribs, and fore limbs. The forms of the cervical ribs are determined, and the composite structure of the scapular arch shown to have characters in common with that of *Dactylosaurus*, *Stereosternum*, and *Plesio-*

saurus. The humerus closely resembles that of the edentate *Megalonyx* before its epiphyses are ossified. There are four bones in the distal row of the carpus, and three bones in the proximal row. The characters of the dorsal surface are given from a specimen preserved in the Albany Museum.

The author then discusses the relation of *Mesosaurus* to *Stereosternum*, as preserved in the British Museum, arriving at the conclusion that the two genera are distinct, defined by characters drawn from all parts of the skeleton. *Stereosternum* has four sacral vertebræ, with the ilium extended far in front of the acetabulum. The coracoids are regarded as meeting in the median line, and not by overlap as in the thin ossification of *Mesosaurus*. In both genera there are five bones in the distal row of the tarsus.

The author concludes that these types are closely allied to *Neusticosaurus*, which he would separate from the Nothosauria and unite with the Mesosauria. That group is subdivided into two divisions—the Proganosauria of Baur, and the Neusticosauria; the former being known from South Africa and South America, and the latter from Europe only.

3. "On a New Reptile from Welte Vreden, *Eunotosaurus africanus* (Seeley)." By Prof. H. G. Seeley, F.R.S., F.G.S.

The author obtained the specimen described at Welte Vreden, near Beaufort West, Cape Colony, where it was found by Mr. L. Pienaar in beds of Middle Karoo age. It indicates a small animal, and shows the dorsal ribs, vertebræ, and part of the pelvis. The centra are more slender than in any known South African fossil, and conically cupped at the ends as in *Mesosaurus*, etc. There is no indication of great transverse widening of the neural arch. The neural spine is compressed. The ribs appear to have been attached much as in Chelonians, though the articulation is not seen. They are remarkably massive, long, wide, compressed above, and subtriangular in transverse section. There may be some sternal ribs. The os pubis is thin and flattened, with a notch on the outer hinder border like that seen in Mesosauria. The genus is probably referable to that group, but distinguished from all known genera by the form of the vertebræ and ribs.

4. "The Dioritic Picrite of White Hause and Great Cockup." By J. Postlethwaite, Esq., F.G.S.

The rock, which is about two miles N.E. of the Little Knott rock, formerly described by Prof. Bonney, was referred to by the author as "a large mass of hornblende picrite of like nature" to the Little Knott rock, in a paper published in the 'Transactions' of the Cumberland and Westmoreland Association for 1889–90. Microscopic examination by Prof. Bonney of the rock which is the subject of the present communication confirms this determination.

The metamorphism observable around this mass is considerably larger than that seen round the Little Knott mass.

5. "On the Structure of the American Pteraspidian, *Palæaspis* (Claypole), with remarks on the Family." By Prof. E. W. Claypole, B.A., D.Sc., F.G.S.

After reviewing the discovery of *Palæaspis* and noticing cases where Scaphaspid plates had been referred to ventral plates of Pteraspidian fish, the author describes two specimens of his genus *Palæaspis* from the Onondaga group (referred to the Lower Ludlow) which indicate the existence of a ventral plate in this genus. The evidence in favour of this interpretation is given at length, and the fossil originally described as *P. bitruncata* is maintained to be the Scaphaspid plate of *P. americana*.

The existence of lateral plates and of lateral organs ('fins') is also discussed, and a comparison made between *Palæaspis* and other Pteraspids. The author attempts a restoration of *Palæaspis*, and gives an amended definition of the genus.

6. "Contributions to the Geology of the Wengen and St. Cassian Strata in Southern Tyrol." By Maria M. Ogilvie, B.Sc. (Communicated by Prof. C. Lapworth, LL.D., F.R.S., F.G.S.)

In the first part of this paper the authoress gives a summary of previous investigations and speculations respecting the sequence and fossils of the Triassic rocks of the well-known Dolomitic region of Southern Tyrol; more especially with reference to the famous fossil-bearing strata of the neighbourhood of St. Cassian. The different views which have been advanced with regard to the actual mode of formation of these strata, and their proper classification, since the appearance of the classical works of Von Richthofen and Mojsisovics, are indicated, and their geological significance discussed.

In the main body of the paper the authoress gives a generalized account of the results of her own personal study of these strata during the years 1891–1892, illustrating her conclusions by maps and sections. Three areas have been partly mapped in detail, on the scale of 1:25000, and the various fossiliferous zones have been traced on the ground. The range and nature of the faults, etc., have in this way been determined.

The typical area of Prelongei and St. Cassian is first described in detail, and from a careful mapping of the ground and a study of the fossils the authoress reaches the conclusion that the St. Cassian strata are naturally separable into three divisions, viz:—

1. *Upper Cassian Beds* (or *Prelongei Zone*).
2. *Middle Cassian* (or *Muren Zone*).
3. *Lower Cassian* (or *Stoures Zone*).

Each division is characterized by certain special lithological features and palæontological characters, everywhere recognizable. In opposition to the views of some other investigators, it is shown, by physical and palæontological evidence that the Upper Cassian series is normally succeeded, as originally asserted by Von Richthofen, by the well-known Schlern Dolomite, and that between this band and the massive Dachstein-Kalk there is invariably found the peculiar zone of the Raibl strata.

The physical and palæontological relationships of the disputed strata of the Richthofen Riff and Sett Sass are next discussed. The richly fossiliferous strata of Heiligenkreuz are shown to include

rocks belonging to all the three zones of St. Cassian, and a part also of the Raibl. Detailed descriptions and illustrations of the disposition of the strata near Cortina d'Ampezzo, Seeland Thal, the Seisser Alpe, etc., are given; and in all cases it is shown that the order recognized in the St. Cassian-Prelongei area is retained practically unmodified, and can be satisfactorily correlated with that of the Upper Trias of the Bavarian Alps.

7. "Notes on some New and Little-known Species of Carboniferous *Murchisonia*." By Miss Jane Donald. (Communicated by J. G. Goodchild, Esq., F.G.S.)

In a previous paper, the various sections into which it has been considered advisable to group different species of *Murchisonia* have been noticed. Of the species described in the present communication, two only can be undoubtedly referred to *Goniostropha* of Œhlert. Others have the sinus situate above the angle; and if this position of the sinual band be considered sufficiently distinctive, the authoress suggests the name *Hypergonia* for this section, and takes *Murchisonia quadricarinata* as the type.

The following new forms are described:—*Muchisonia* (*Goniostropha*) *hibernica*, *M.* (*G.*) *Tatei*, *M.* (*Hypergonia*) *quinquecarinata*, De Kon., var. *pulchella*, *M.* (*H.*) *conula*, De Kon., var. *convexa*, *M.* (*H.*) *pentonensis*. *M.* (*H.*) *Kirkbyi*, *M.* (*H.*) *plana*, *M.* (*Cœlocaulus*?) *tuedia*.

A fuller description is also given of a species previously described by Prof. Haughton under the name of *Cerithioides telescopium*.

8. "Notes from a Geological Survey in Nicaragua." By J. Crawford, Esq., State Geologist to the Nicaraguan Government. (Communicated by Prof. J. Prestwich, LL.D., F.R.S., F.G.S.)

Nicaragua, geologically considered, can be divided, from north to south, into five zones, differing from one another in lithological, mineralogical, and structural characters.

The first division embraces the central mountainous parts, and contains Laurentian, Taconian, Cambrian, and Silurian rocks, also Devonian rocks unconformable to the last. The second division, parallel to that just named, and extending to within a hundred miles of the Caribbean sea, contains sediments of Carboniferous, Permian, and Mesozoic ages, covered unconformably by Cainozoic and modern formations. In some of the rivers of this division are rich gold-placers. The third division is the delta on the eastern coast. Evidence furnished by alluvial deposits and coral-reefs indicates recent subsidence until a few years ago, when elevation commenced. The fourth division is on the western side of the first (central) division. Its rocks are generally similar to those of the second division. In some places dykes are connected with lava-flows. In the valley of the Rio Viejo is a Tertiary mammaliferous deposit with Tillodonts, etc. The fifth division occupies Western Nicaragua, and contains several small crater-lakes of the Vicksburg, Yorktown, and Sumpter periods; all the post-Mesozoic Nicaraguan volcanoes are in this division.

Details of the economic products, the volcanic phenomena, and the

glaciation of the country are furnished, and the remains of Neolithic man are recorded.

9. "Microzoa from the Phosphatic Chalk of Taplow." By F. Chapman, Esq., F.R.M.S. (Communicated by Prof. T. Rupert Jones, F.R.S., F.G.S.)

Ninety-eight species and varieties of Foraminifera, and five species and varieties of Ostracoda have been found in this deposit. All the forms of Ostracoda have been previously found in the Chalk. Of the 98 varieties of Foraminifera five appear to be new, whilst altogether thirty are new to the Chalk fauna.

The following new forms are described:—*Nubecularia Jonesiana*, *Textularia decurrens*, *T. serrata*, *Bulimina trigona*, and *Bolivina strigillata*.

10. "On the Basalts and Andesites of Devonshire, known as Felspathic Traps." By Bernard Hobson, Esq., M.Sc., F.G.S.

The evidence in favour of the contemporaneous (non-intrusive) character of these Permian (or Triassic) lavas is discussed, and the improbability of the former existence of felspathic traps in the area of the Dartmoor granite, as suggested by Mr. R. N. Worth, is shown. The macroscopical and microscopical characters of the rocks are described. The great majority of the rocks examined are olivine-basalts, though mica-augite-andesite occurs at Killerton, near Exeter. The presence of quartz-inclusions in the rocks of West Town, Knowle, etc., near Exeter, is shown to have misled De la Beche into terming these rocks quartz- ('quartziferous') porphyries. The veins in the traps, mentioned by Mr. Vicary, and regarded by some authors as intrusive felsite dykes, are found to be red-stained veins of calcite and sandstone.

11. "Notes on Recent Borings for Salt and Coal in the Tees Salt-District." By Thomas Tate, Esq., F.G.S.

The Tees Salt industry has expanded considerably since Mr. E. Wilson's exhaustive paper was read in June, 1888.

The results of subsequent borings have in most cases simply confirmed previously ascertained facts, but the two boreholes with which this paper principally deals, put down on the White House estate, three miles due west of Stone Marsh, may be useful in relation to the determination of (*a*) the area of the Tees Salt-field, and (*b*) the southern limit of the Durham Coal-basin.

After boring through 115 feet of Drift deposits and 151 feet of Red Sandstones and Marls, the Saliferous Marls, at the base of which the Salt-rock, when present, is usually found sandwiched between two beds of anhydrite, were reached, having a thickness of 178 feet, but with no Rock-salt. The Magnesian Limestone formation, only 299 feet thick, an unusually large proportion of which is gypsum or anhydrite, was succeeded by grey sandstones, rich in calcite, probably due to infiltration. The carbonaceous shales and sandstones with bands of encrinital limestone below these, together with their contained fossils, determine their identity with the Yoredale Series. Total depth, 1079½ feet.

The chief results are:—(1) the Upper Keuper Red Marls are

wanting (as in nearly every borehole north of the Tees); (2) the Salt-rock is absent and the Red Marl overlying its horizon is not 'rotten marl' but compact; (3) the Magnesian Limestone (299 feet) is the thinnest complete section in County Durham; (4) no coal is found; (5) the Yoredale Rocks are represented by 336½ feet of grey sandstones and encrinital limestones, carbonaceous shales, ironstone nodules and carbonaceous sandstones.

An Appendix, containing full details of the two vertical sections, accompanies the paper.

CORRESPONDENCE.

CONCRETIONS.

Sir,—Is not carbonic acid evolved from decaying organisms? If lime were present in the water in which such decomposition were taking place, would not the acid combine with the base to form a carbonate of lime?

Would not the precipitation of this salt first take place immediately around the organic nucleus, and form a covering which would enclose the decomposing matter? This covering would not only retard future chemical action, but would confine it to a much narrower limit, viz. the centre of the embryonic concretion.

But as the decomposition of the organic matter would not necessarily at this stage be arrested, would not the CO_2 gradually ooze through the thin crust, and the chemical action continue, though more slowly, as before, causing a gradual thickening of the concretion through external precipitation.

The greater the distance from the nucleus, the weaker would this action become, and the concretion would finally reach a point at which—owing either to a failure in the supply of the CO_2, or the inability of the same to penetrate the increased thickness of $CaCO_3$—it would cease to grow.

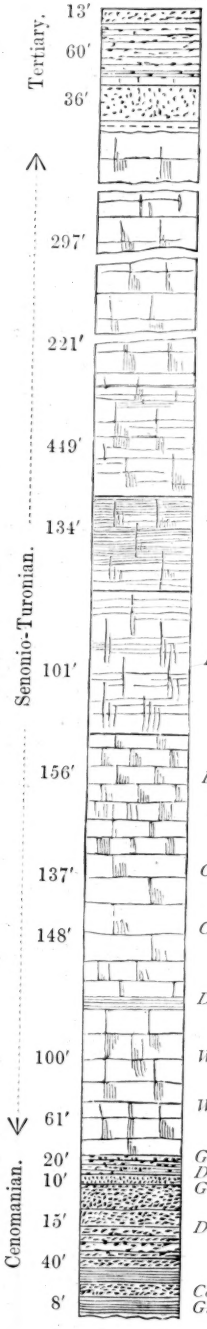
Would not this theory account for the formation of *Sphæosiderites*, and other nodules containing organic nuclei? Would it not also explain why these so often increase in hardness towards their centres?

C. C. W.

MISCELLANEOUS.

York Museum.—We learn from York that the late Mr. William Reed, F.G.S., whose obituary notice we published in our June Number (p. 283), has most generously bequeathed to the Yorkshire Philosophical Society the sum of **£600** the interest of which is to be expended on the Museum which has already been so greatly enriched by the various donations of collections presented by Mr. Reed in past years.

VERTICAL SECTION OF STRATA AT KHARKOV, SOUTH RUSSIA, DISPLAYED BY ARTESIAN BORING.



Black Earth.
Grey Sand (? Miocene).
Blue Sandy Clay.

Less sandy at base.
Phosphorite layer.
Light Blue running sands. } *Oligocene and Eocene.*
Clays and Sandstones

White Chalk (soft).
Similar lithologically to White Chalk of Bielgorod rich in Bel. mucronata.

White Chalk somewhat more compact.

White Chalk less compact and with bluish tinge.

Bluish Chalk (somewhat more clayey).

Bluish Chalk Marl.

Blue Chalk Marl. Alternately darker and lighter.

Grey firm Chalk.

Chalk like the above, but whiter and softer.

Ditto with fragments of Belemnite and Inoceramus.

White Chalk.

White soft Chalk.

Greenish Sandy Clay.
Dark Green Sand.
Grey and Greenish Sands.

Dark Green Sand.

Coarse light Grey Sand with fossil wood (Jurassic, according to Grey Clay. [*Prof. Gourov*).